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AIRWORTHINESS AND FLIGHT CHARACTERISTICS EVALUATION IMPROVED MAIN ROTOR BLADE INSTALLED ON A YAH-1R HELICOPTER.

(9) FINAL REPORT.

(10)

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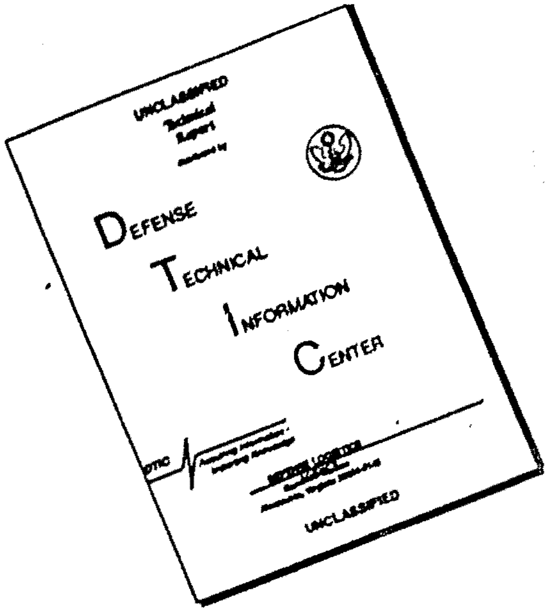

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The United States Army Aviation Engineering Flight Activity conducted an airworthiness and flight characteristics evaluation of the Kaman Aerospace Corporation improved main rotor blade (K-747) installed on a YAH-1R helicopter. The Bell Helicopter Textron YAH-1R was tested from 25 February through 10 June 1977 at three sites in California: Edwards Air Force Base (2302-foot elevation),		

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20. Abstract

Bishop (4120-foot elevation), and Coyote Flats (9980-foot elevation). A total of 82.9 test flight hours were flown of which 44.7 hours were productive. Bell B-540 and Kaman K-747 rotor blades were evaluated for performance, limited stability and control characteristics, and miscellaneous engineering items. The results of the B-540 blade tests were used as a base line for comparison with the K-747 test results. The YAH-1R helicopter with K-747 blade installed exhibited performance improvements in hover, climb, and portions of the level flight envelope. Maximum gross weight for out-of-ground effect hover on a 4000-foot, 35°C day was improved by 3.5 percent, but failed to meet the desired 6 percent of the Request for Proposal or the specified 8.7 percent improvement of the Detail Specification. The change in level flight performance of the YAH-1R caused by the installation of K-747 blades varied with thrust coefficient and airspeed. Limited handling qualities tests showed no change in flight characteristics between blades; therefore, a separate pilot standardization program for the AH-1 series with the K-747 blade installed is not considered necessary. The dual hydraulic system failure characteristics with the K-747 blades were significantly degraded and current handbook procedures for safely landing the YAH-1R with dual hydraulic system failure will have to be revised. Vibration levels in the YAH-1R were essentially unchanged with the K-747 rotor blade. During the flight test program, several cracks in the blades and blade-to-hub attachment occurred and adequate published criteria to determine the severity of these cracks did not exist. The ease of repair of the K-747 blade and the minimal down time required to effect such repairs was an enhancing feature. No deficiencies or shortcomings were identified. The inability to store or ship the B-540 blade in the K-747 containers is undesirable.

DEPARTMENT OF THE ARMY
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DRDAV-EQ

MAY 25 1978

SUBJECT: USAAEFA Project No. 76-08 Airworthiness and Flight Characteristics Evaluation Improved Main Rotor Blades Installed on a YAH-1R Helicopter, November 1977

SEE DISTRIBUTION

1. The purpose of this letter is to present the Directorate for Development and Engineering position on the subject report.

2. Specific comments by paragraph are:

a. Abstract, last sentence - This sentence should state that there is no requirement to store or ship the B 540 blade in the K-747 container.

b. Paragraph 5 - While this paragraph states that "Only the hover performance design requirement of paragraph 3.2.2.2.2.d of the IMRB detail specification (reference 11) was checked", in fact the performance of the IMRB in all flight regimes was evaluated.

c. Paragraph 42 - Instructions on page 26 which cover dual hydraulic system failure with the K-747 IMRB should state under WARNING that "cyclic feedback forces become uncontrollable below 50 KIAS" not 40 KIAS as listed.

d. Paragraph 47 - Should be deleted since there is no requirement to store or ship the B540 blade in the K-747 container.

e. Paragraph 54 - Concur with the general conclusions contained in this paragraph.

f. Paragraph 55 - Concur with the specific conclusions listed in this paragraph except for sub-paragraph 55g. No requirement exists to store or ship the B540 blade in the K-747 container.

g. Paragraph 56 - No further testing should be required. Quantitative methods can be used to define the autorotational descent performance of the AH-1S with K-747 rotor blades.

h. Paragraph 57 - Separate emergency procedures for Hydraulic Systems Failures (K-747 Rotor) will be incorporated when further testing is completed.

i. Paragraph 58, 59 and 60 - Action has been taken to incorporate the intent of these recommendations.

j. Appendix E, Figure 32 - Maximum Continuous Power (MCP) limit should read "Maximum Torque Limit above 100 KIAS." The line for Takeoff Power Limit should be deleted.

FOR THE COMMANDER:

Walter A. Ratcliff
WALTER A. RATCLIFF
Colonel, GS
Director of Development
and Engineering

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INTRODUCTION

BACKGROUND

1. The United States Army Aviation Systems Command (AVSCOM)* awarded a development contract to Kaman Aerospace Corporation (KAC) in May 1975 to design, fabricate, and test an improved main rotor blade (IMRB) for the AH-1 series helicopter. The design objectives of the program were to provide improved hover performance, reduce ballistic vulnerability, and improve reliability and maintainability. The IMRB design includes the use of an advanced design airfoil, a tapered tip planform, composite material construction, and a multicell ballistically tolerant spar. An Army Preliminary Evaluation (APE) of the IMRB was completed at the KAC plant facility in Bloomfield, Connecticut, by the United States Army Aviation Engineering Flight Activity (USAAEFA) in November 1976 (ref 1, app A). AVSCOM directed USAAEFA to conduct an Airworthiness and Flight Characteristics (A&FC) evaluation of the YAH-1R helicopter with IMRB installed (refs 2 and 3). In February 1977 USAAEFA published the test plan for the A&FC (ref 4).

TEST OBJECTIVES

2. The objectives of the A&FC of the YAH-1R with IMRB installed were as follows:

a. Determine the airworthiness and flight characteristics of the YAH-1R with IMRB installed.

b. Determine compliance with the requirements of the detail specification (ref 5, app A).

c. Obtain data for use in the AH-1S operator's manual (ref 6)

d. Determine the handling qualities differences between the IMRB (K-747) and the standard Bell 540 rotor (B-540) following a dual hydraulic failure.

e. Identify any deficiencies and shortcomings.

*Since redesignated the United States Army Aviation Research and Development Command (AVRADCOM).

DESCRIPTION

3. The YAH-1R helicopter is a modified version of the AH-1G helicopter and is manufactured by Bell Helicopter Textron (BHT). The YAH-1R is a tandem two-seat single-lifting-rotor attack helicopter. AH-1S wings were installed for this evaluation to accommodate the TOW pods. The appearance and overall dimensions of the YAH-1R are the same as the AH-1G except for those dimensions pertaining to the Model 212 tail rotor and the internal construction and location of jack points of the wings. A detailed description of the AH-1G helicopter is contained in the AH-1G operator's manual (ref 7, app A) and the S model armament systems in the AH-1S operator's manual. A detailed description of the Model 212 tail rotor is contained in USAASTA Final Report No. 72-30 (ref 8). The Model 212 tail rotor used in the YAH-1R differed from that described in reference 8 only in the rigging of the maximum tail rotor blade pitch angle. The maximum blade pitch angle was larger (19.9 degrees) in the YAH-1R because of the uprated tail rotor drive train. The aircraft empty weight was increased approximately 61 pounds, and the maximum allowable gross weight was increased from 9500 to 10,000 pounds. Internal modifications applied to the AH-1G airframe to develop the YAH-1R include the following:

a. Installation of a T53-L-703 engine with a thermodynamic rating of 1800 shaft horsepower (shp) and an engine torque limit of 1175 foot-pounds (ft-lb) (1500 shp).

b. Installation of a modified AH-1J transmission rated at 1290 shp for 30 minutes and 1134 shp continuous operation.

c. Installation of a modified AH-1J tail rotor drive system allowing 187 shp continuous and a transient power limit of 260 shp for 4 seconds.

d. Strengthened transmission mounts and associated structures, and tail boom.

e. Installation of push-pull tubes replacing cables in the tail rotor control system.

4. The IMRB incorporates an advanced design airfoil, a tapered tip planform, composite material construction, and a multicell ballistically tolerant spar. The blades are designed to be individually interchangeable and when used as a set, are interchangeable with the standard AH-1 main rotor blades without

modification other than pitch link adjustment. A more detailed description of the test aircraft (SN 70-15936) and the IMRB, including photos, is provided in appendix B.

TEST SCOPE

5. The limited A&FC evaluation of the IMRB was conducted at Edwards Air Force Base (2302-foot elevation), Bishop (4120-foot elevation), and Coyote Flats (9980-foot elevation), California, from 25 February through 10 June 1977. A total of 77 test flights (44.7 productive hours) were accomplished at the test conditions and configurations shown in table 1. One YAH-1R test helicopter (SN 70-15936) was used throughout the A&FC evaluation. Flight limitations contained in the safety-of-flight release (ref 9, app A), and the operator's manual were observed during the evaluation. Handling qualities and vibration levels were evaluated with respect to the applicable requirements of military specification MIL-H-8501A (ref 10). Only the hover performance design requirement of paragraph 3.2.1.1.1.d. of the IMRB detail specification (ref 11) was checked to determine if it met the required improvements. The lack of YAH-1R base-line performance data necessitated testing both the B-540 and the K-747 blades to obtain a performance increment attributable to the K-747 blade.

6. By verbal and written amendment (ref 3, app A), the scope of the tests was substantially altered, deleting several tests and greatly expanding the hover performance tests. The number of blade sets was expanded from two to five, as shown in table 2, to test for performance differences caused by variations in blade surface condition.

TEST METHODOLOGY

7. Test methods and data reduction procedures used in these tests were standard engineering flight test techniques (refs 12 through 15, app A) and are described briefly in appendix D. A Handling Qualities Rating Scale (HQRS) (app D) was used to augment pilot comments. Flight test data were obtained from test instrumentation displayed on the pilot and copilot panels and recorded on magnetic tape. A data acquisition/computer van incorporating an EMR 6135 computer was used for real time telemetry monitoring of selected critical data parameters during certain tests and for data processing at the high-altitude test site. A detailed listing of the test instrumentation is contained in appendix C.

Table 1. Test Conditions.

Type of Test	Rotor Blades	External Configuration[1]	Gross Weight (lb)	Center-of-Gravity Location		Density Altitude (ft)	Outside Air Temperature (C°)	Trim Calibrated Airspeed (kt)	Rotor Speed (RPM)
				Longitudinal (FS)	Lateral (BL)				
Hover performance[2]	B-540	8-TOW & clean	7960 to 9960	194.5 (mid) to 195.4 (mid)	0.1 rt to 0.2 rt	1000 to 10920	1.5 to 19.5	Zero	292 to 331[3]
	K-747	8-TOW & clean	7960 to 10200	194.8 (mid) to 196.7 (mid	0.1 rt to 0.2 rt	1520 to 10700	-6.5 to 15.5	Zero	293 to 336[3]
Climb performance	B-540	8-TOW	8820 to 9240	194.3 (mid) to 194.8 (mid)	0.1 rt to 0.2 rt	2320 to 5480	3.5 to 14.0	64	324
	K-747	8-TOW	8820 to 9480	195.8 (mid) to 196.3 (mid)	0.1 rt	3960 to 10440	2.0 to 4.5	64	324
Level flight performance	B-540	8-TOW	8660 to 9680	194.2 (mid) to 195.0 (mid)	0.2 rt	1060 to 1120	-2.0 to 12.0	29 to 141	313 to 323
		Clean	8100 to 8600	194.9 (mid) to 195.3 (mid)	0.2 rt	3040 to 10600	4.0 to 8.0	34 to 146	312 to 322
	K-747	8-TOW	9320 to 9960	195.1 (mid) to 196.0 (mid)	0.1 rt	2620 to 11700	0.5 to 18.0	38 to 136	320 to 324
		Clean	7720 to 8240	194.7 (mid) & 195.0 (mid)	0.1 rt	7100 to 8600	13.0 & 9.0	39 to 142	316 & 319
Autorotational descent performance	K-747	8-TOW	9140	196.0 (mid)	0.1 rt	5000	2.5	56 to 110	321
Control positions in trimmed forward flight	B-540	8-TOW	8660 to 9680	194.2 (mid) to 195.0 (mid)	0.2 rt	1060 to 11200	-2.0 to 12.0	29 to 141	313 to 323
		Clean	8100 to 8600	194.9 (mid) to 195.3 (mid)	0.2 rt	3040 to 10600	4.0 to 8.0	34 to 146	312 to 322
	K-747	8-TOW	9320 to 9960	195.1 (mid) to 196.0 (mid)	0.1 rt	2620 to 11700	0.5 to 18.0	38 to 136	320 to 324
		Clean	7720 & 8240	194.7 (mid) & 195.0 (mid)	0.1 rt	7100 & 8660	13.0 & 9.0	39 to 142	316 & 319
Maneuvering stability[4]	K-747	8-TOW	9200 to 9780	199.5 (aft) to 199.6 (aft)	0.1 rt	4340 to 6900	0.5 to 3.5	120	324
Simulated sudden engine failure	K-747	8-TOW	9680 & 9820	200.2 (aft)	0.1 rt	5560 & 5300	7.5 & 8.0	130 & 73	318 & 317
Dual boost hydraulic failure[5]	B-540	Heavy TOW	9600 to 10000	194.2 (mid) to 194.7 (mid)	0.1 rt	2820 to 4450	12.0 to 14.0	72,102,124	324
	K-747	Heavy TOW	9400 to 10000	194.2 (mid) to 194.7 (mid)	0.1 rt	3730 to 6110	20.5 to 24.5	72,102,124	324

[1]Clean: No stores; 8-TOW launchers with four simulated missiles on each outboard station; Heavy TOW: One M-200 launcher on each inboard station and two TOW launchers with four simulated missiles on each outboard station.
[2]Free flight hover at skid heights of 5 and 100 feet.
[3]Referred rotor speeds.
[4]Left and right turns, pushover and pull-ups.
[5]Shallow banking turns not exceeding 15 degrees angle of bank, altitude changes, and shallow angle running type approaches.

Table 2. Main Rotor Blade Configuration.

Blade Set[1]	Serial No.	Surface Condition	Flight Hours[2]	Performance Tests	Test Site Elevation (ft)
K-747	1005 & 1009	Smooth	124[3] & 104	Hover	2302, 4168 9980
				Level flight	2302
				Climb	4168
				Autorotational descent	4168
K-747	1013 & 1014	Smooth with repair patches	97	Hover	4168, 9980
K-747	1025 & 1026	Rough - able to feel basket	6	Hover	2302
				Level flight	
B-540	A2-08063 & A2-08109	Minor erosion at leading edge	115	Hover	2302
				Level flight	
				Climb	
B-540	A2-6500 & A2-6502	Significant erosion at leading edge, dents at top & botton	360	Hover	4168, 9980

[1]K-747: Prototype blades manufactured by Kaman Aerospace Corporation.
B-540: Production blades manufactured by Bell Helicopter Company, Textron.
[2]Flight hours at time of first test installation.
[3]Blade 1005 - 124 hours, Blade 1009 - 104 hours.

RESULTS AND DISCUSSION

GENERAL

8. The performance of the YAH-1R with K-747 blade installed was slightly altered and handling qualities for normal operations were unchanged. Based on these tests, it was determined that a separate pilot standardization program for the AH-1 series helicopter with K-747 blade installed would not be necessary. However, a separate section on dual hydraulic system failure emergency procedures should be included in the operator's manual because of degraded handling qualities due to the installation of the K-747 blade.

PERFORMANCE

General

9. YAH-1R performance was evaluated at the conditions shown in table 1. Five sets of blades, two BHT B-540 and three KAC K-747, were utilized during the hover performance evaluation. The performance of the YAH-1R was improved with installation of the K-747 blade, but hover performance failed to meet the desired 6 percent improvement of the Request for Proposal (RFP) (ref 16, app A) or the 8.7 percent improvement of the detail specification.

Hover Performance

10. Hover performance tests were conducted to determine power required at the conditions presented in table 1. The free flight hover method (app D) was used at skid heights of 5 and 100 feet. The tests were conducted with five different sets of rotor blades (three sets of K-747 and two sets of B-540) at three different test sites. A comparison of the surface condition of the various rotor blades is presented in table 2. A comparison of the hover capability of the K-747 and B-540 blades is presented in figures 1 and 2, appendix E. Summaries of hover capability of each set of blades are presented nondimensionally in figures 3 through 8.

11. Hover performance of the K-747 blade was better than the B-540 blade at all thrust coefficients (C_T) tested. The maximum gross weight at which the aircraft could hover out of ground effect (OGE) (at 4000 feet, 35°C, takeoff power) varied depending on blade condition of the K-747 blade. The maximum gross weight

was independent of blade surface condition for the two sets of B-540 blades. Table 3 summarizes the hover capability of the YAH-1R equipped with the various blade sets at the design requirement conditions. As shown in table 3, the maximum OGE hover gross weight varied from 9205 to 9390 pounds for the K-747 blade and was 9070 pounds for the B-540 blade. This represents an increase of from 135 to 320 pounds of gross weight with the K-747 blade. This gross weight increase represents an improvement of between 1.5 and 3.5 percent over the B-540 blade. The K-747 IMRB hover performance was improved over that of the B-540 but failed to meet the desired 6 percent increase in OGE hover gross weight of the RFP or the specified 8.7 percent improvement of the detail specification.

Table 3. OGE Hover Performance.[1]

Type of Blade	Rotor Blade		Maximum OGE Hover Gross Weight (lb)
	Serial No.	Surface Condition	
B-540	A2-08062 & A2-08109	Minor erosion at leading edge	9070
	A2-6500 & A2-6502	Significant erosion at leading edge, dents at top & bottom	9070
K-747	1005 & 1009	Smooth	9390
	1013 & 1014	Smooth with repair patches	9205
	1025 & 1026	Rough - able to feel basket weave	9327

[1]4000 - foot pressure altitude, 35°C day, take off power (1185 shp).

12. Tail rotor data were obtained in conjunction with hover performance. The results of these tests are presented in figures 9 through 12, appendix E.

Climb Performance

13. Tests were conducted using the sawtooth climb test method (outlined in app D) to determine the climb performance of the YAH-1R equipped with B-540 rotor blade and the K-747 rotor blade. The tests were conducted with the aircraft in the 8-TOW configuration at the conditions listed in table 1. Correction factors for variations in power (K_P) and gross weight (K_W) were also determined. Climb performance of the YAH-1R was improved with installation of the K-747 blade. Summaries of climb performance for both blade sets at standard day and 35°C conditions are presented in figures 13 and 14, appendix E.

14. Above 10,000 feet pressure altitude and at all gross weights, the K-747 blade improved the climb performance of the YAH-1R. At lower altitudes, the rates of climb of the aircraft with K-747 blade were generally equal or better than with the B-540 blade. At the specific conditions of 10,000 pounds gross weight, 4000 feet pressure altitude, and 35°C (95°F) day, the aircraft's maximum rate of climb was 1280 feet per minute (ft/min) with the B-540 blade and 1425 ft/min with the K-747 blade. This represents an increase in climb capability of 145 ft/min (11 percent) with the K-747 blade installed.

15. The generalized climb and descent performance data are presented in figures 15 and 16, appendix E, and dimensional forward flight climb performance for the two rotor configurations is shown in figures 17 and 18. K_P values of .822 for the B-540 blade and .800 for the K-747 blade were determined from the generalized climb performance data using the analysis method presented in appendix D. Nondimensional rate of climb (μ_V) as a function of C_T is presented in figure 19 and shows that K_W was identical for both rotor configurations.

Level Flight Performance

16. Level flight performance tests were conducted to determine power required and fuel flow as functions of airspeed. In addition, specific range, recommended airspeed for long range cruise (V_{cruise}), airspeed for maximum endurance at minimum power required for level flight ($V_{max\ end}$), and maximum airspeed for level flight at maximum power allowable (V_H) were determined.

Data were obtained in stabilized level flight (zero sideslip) at incremental airspeeds from 30 knots calibrated airspeed (KCAS) to V_H using the methods described in appendix D. Flight tests were conducted with the aircraft in the clean and 8-TOW configurations with B-540 and K-747 blades. Average test conditions for level flight performance are shown in table 1.

17. Nondimensional level flight performance summaries are presented for both the B-540 and K-747 blades in figures 20 through 24, appendix E. Figures 25 through 42 are dimensional plots of the individual level flight performance tests accomplished. Aircraft specific range, $V_{max\ end}$, V_{cruise}, and V_H in level flight for the 8-TOW configuration are summarized in figures 43 through 46.

18. The change in level flight performance of the YAH-1R caused by the installation of the K-747 blade varied with C_T and airspeed. Figure A summarizes this variation. For airspeed and C_T combinations above the curve, performance was improved by the K-747 blade. For airspeed and C_T values below the curve (hatched area), the B-540 blade provided slightly better level flight performance. The magnitude of performance improvement or degradation caused by the K-747 blade cannot be determined from this figure. No data were obtained between hover and 40 knots true airspeed (KTAS) but the hover data indicated that the K-747 blade improved YAH-1R performance at all C_T values (para 11).

19. Figure B shows a level flight performance comparison at the specific conditions of 10,000 pounds gross weight, 4000 feet pressure altitude, and 35°C (95°F). This figure, which represents a heavily loaded condition (C_T = 0.00615), shows an increase in V_H of approximately 8 KTAS and indicates improved endurance for the K-747 blade. At airspeeds between 40 and 57 KTAS, however, the B-540 blade provided better performance. The results are summarized in table 4. Figure C shows a level flight performance comparison at a comparatively lightly loaded condition (8700 pounds gross weight, 5000 feet pressure altitude, standard day, C_T = 0.00501). This figure indicates slightly degraded performance with the K-747 blade throughout the airspeed range shown. (The K-747 blade showed improved hover performance at all weights tested.)

20. The change in equivalent flat plate area (Δf_e) between the clean and 8-TOW external stores configurations was a constant 5.1 square feet (ft^2) at all conditions tested with either set of blades installed. This is different from the value of 6.5 ft^2 published in the operator's manual. Although higher level flight

FIGURE A
LEVEL FLIGHT PERFORMANCE COMPARISON FOR K747 AND B540 BLADES
YAH-1R USA S/N 70-15936
ROTOR SPEED = 324 RPM

NOTE: DATA DERIVED FROM FIGURES 20 THROUGH 24, APP E

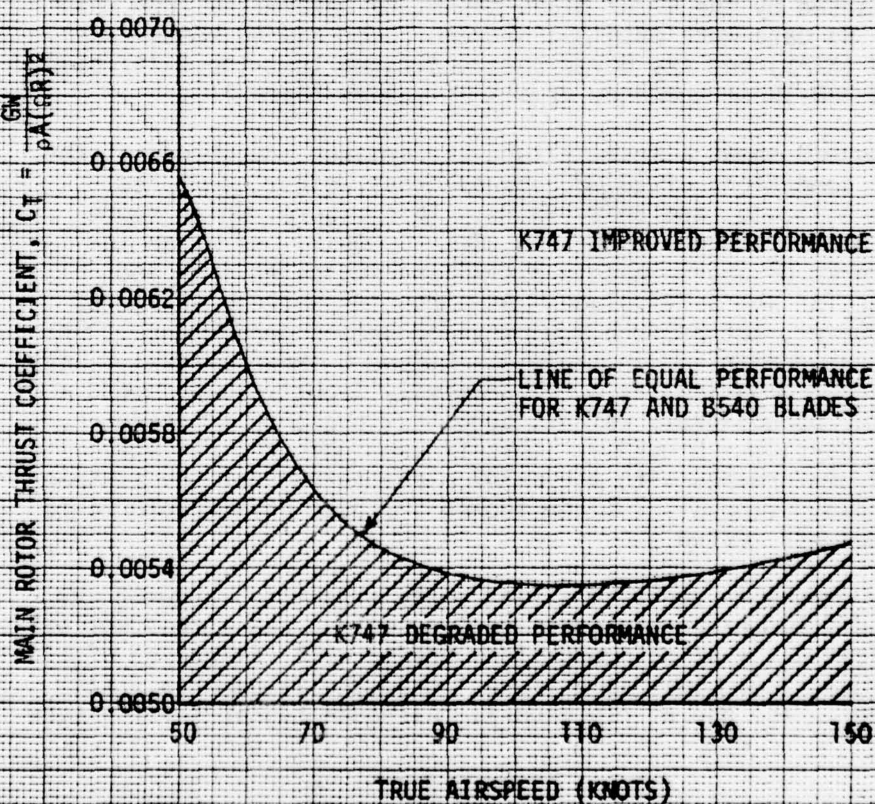


FIGURE 8
LEVEL FLIGHT PERFORMANCE COMPARISON
YAH-1R USA S/N 70-15936

GROSS WEIGHT (LB)	LONG CG LOCATION	PRESSURE ALTITUDE (FT)	OAT (°C)	ROTOR SPEED (RPM)	C_T	CONFIGURATION
10000	MID	4000	35	324	.00615	8-TOW

NOTES: 1. SPECIFIC RANGE BASED ON SPECIFICATION FUEL FLOW INCREASED 5%.
2. SHP VS V_T CURVES DERIVED FROM FIGS. 20 THROUGH 24, APP E.
3. ENGINE CHARACTERISTICS BASED ON SPEC WITH INSTALLATION LOSSES PER APP D.
4. ZERO SIDESLIP.

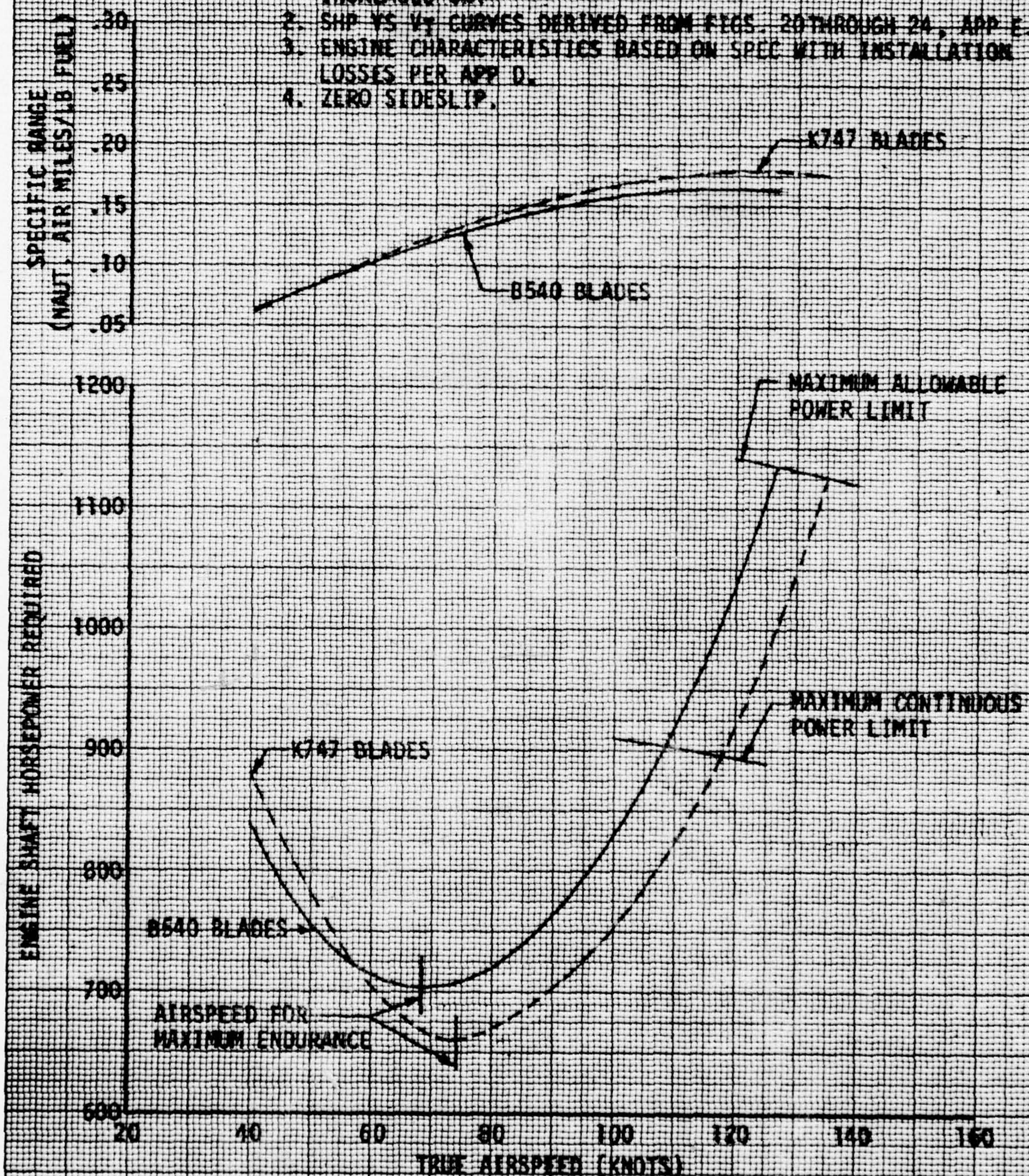


Table 4. Summary of Maximum Airspeed, Specific Range, and Endurance.[1]

Rotor Blade	Minimum Power Required Airspeed (kt)	Recommended Endurance Airspeed (kt)	Recommended Cruise Airspeed (kt)	Specific Range at Recommended Endurance Airspeed (NAMPP)[2]	Specific Range at Recommended Cruise Airspeed (NAMPP)	Endurance[3] at Recommended Airspeed (hr)	Range at[3] Recommended Cruise Airspeed (naut mi)	Maximum Airspeed (kt)
B-540 blades	68	71	108	.122	.160	2.63	245.2	126.8
K-747 blades	74	80	118	.142	.178	2.72	272.8	135.0
K-747 blades percent improvement	8.8	12.7	9.3	16.4	11.3	3.4	11.3	6.5

[1]Based on 10,000 pounds, 4000 foot, 35°C, 324 rpm, 8-TOW configuration, fuel flow 5 percent conservative.
[2]Nautical air miles per pound of fuel.
[3]Based on 262 gallon crashworthy fuel system at 6.5 lb/gallon allowing 10 percent reserve (no allowance for tart, takeoff, climb or landing).

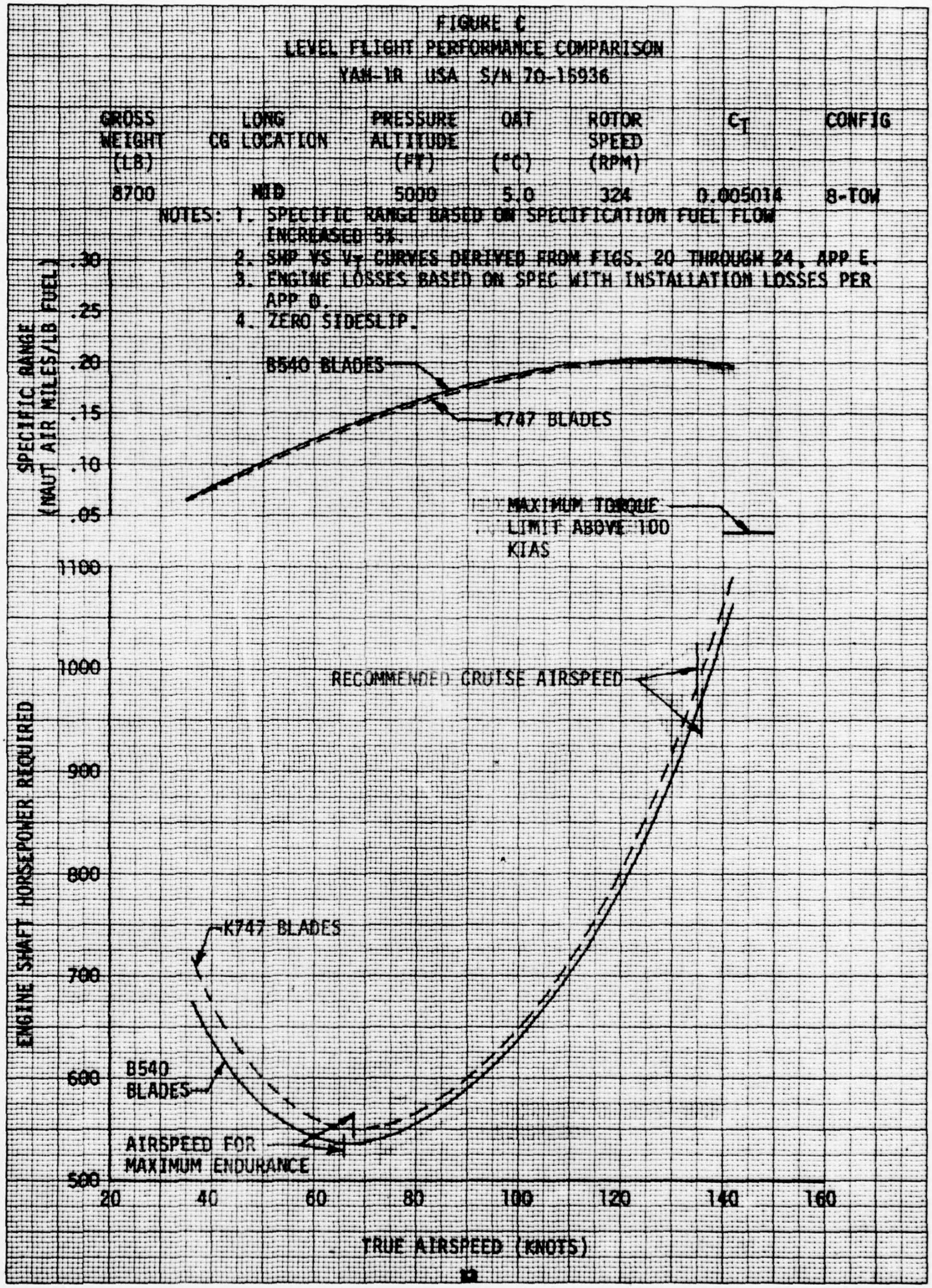


FIGURE C
LEVEL FLIGHT PERFORMANCE COMPARISON
YAH-1R USA S/N 70-15936
GROSS WEIGHT (LB)
LONG CG LOCATION
PRESSURE ALTITUDE (FT)
OAT (°C)
ROTOR SPEED (RPM)
C_T
CONFIG
8700
MID
5000
5.0
324
0.005014
8-TOW
NOTES: 1. SPECIFIC RANGE BASED ON SPECIFICATION FUEL FLOW INCREASED 5%.
2. SHP VS V_T CURVES DERIVED FROM FIGS. 20 THROUGH 24, APP E.
3. ENGINE LOSSES BASED ON SPEC WITH INSTALLATION LOSSES PER APP D.
4. ZERO SIDESLIP.
SPECIFIC RANGE (NAUT AIR MILES/LB FUEL)
.30
.25
.20
.15
.10
.05
B540 BLADES
K747 BLADES
MAXIMUM TORQUE LIMIT ABOVE 100 KIAS
ENGINE SHAFT HORSEPOWER REQUIRED
1100
1000
900
800
700
600
500
RECOMMENDED CRUISE AIRSPEED
K747 BLADES
B540 BLADES
AIRSPEED FOR MAXIMUM ENDURANCE
20
40
60
80
100
120
140
160
TRUE AIRSPEED (KNOTS)

airspeeds could be obtained with the K-747 blade installed, test results indicate that the V_H is always less than the never-exceed airspeed (V_{NE}).

Autorotational Descent Performance

21. Autorotational descent performance tests of the YAH-1R with K-747 rotor blade installed were conducted in the 8-TOW configuration at the conditions shown in table 1. The results of these tests are presented in figure 47, appendix E.

22. The minimum rate of descent was 1905 ft/min at 70 KCAS. Airspeed for maximum glide distance was 98 KCAS, which resulted in a 2240-ft/min rate of descent and a glide ratio of 4.7:1. Due to differences in the external configuration of the YAH-1R and the AH-1S aircraft, valid AH-1S autorotational performance cannot be implied from these tests. It is recommended that further autorotational descent performance testing be conducted on the AH-1S using the K-747 rotor blade to obtain data for the AH-1S operator's manual.

HANDLING QUALITIES

General

23. The handling qualities of the YAH-1R with IMRB installed were not changed from those previously reported on the AH-1 series aircraft with the B-540 blade installed, except during dual boost failed mode operation. With both hydraulic boost systems failed, handling qualities with the K-747 blade installed were sufficiently changed from those exhibited with the B-540 installed that a change to the operator's manual emergency procedures is required.

Control Positions in Trimmed Forward Flight

24. Control positions in trimmed forward flight were evaluated from 30 to 140 KCAS with the stability and control augmentation system (SCAS) ON, in both the clean and 8-TOW configurations at the conditions listed in table 1. Test results are presented in figures 48 through 51, appendix E.

25. The longitudinal control positions in trimmed forward flight showed no significant change due to the blade change and are satisfactory.

26. The maximum lateral and directional control position changes were less than 1 inch throughout the airspeed range tested. The migrations were gradual and not discernible to the pilot throughout the airspeed envelope tested. Lateral and directional control position characteristics were independent of blade type installed, and are satisfactory.

Maneuvering Stability

27. Maneuvering stability characteristics were evaluated at the conditions shown in table 1. Trim condition was 120 KCAS, power for level flight, and zero sideslip. The variation of longitudinal and lateral cyclic and pedal control positions with normal acceleration was determined with the aircraft stabilized in constant-airspeed turns at incremental bank angles both to the left and right. The collective control remained fixed during the maneuver; power and rotor speed varied as a function of load factor during the turn. Symmetrical pull-ups and pushovers were also conducted to the limit normal acceleration. The quantitative results of maneuvering stability are presented in figure 52, appendix E.

28. Stick-fixed and stick-free maneuvering stability was positive at load factors less than 1.52 (4 in./g and 7.4 lb/g, respectively). At load factors greater than 1.52 stability was neutral because the longitudinal SCAS reached the limit of its travel (see ref 17, app A, for further explanation). Control of airspeed and load factor was adequate to accomplish required mission maneuvers.

29. As load factor was increased during maneuvering flight the 2-per-rotor-revolution (2/rev) vertical vibration increased. Cyclic feedback was encountered at 1.8g. Engine overspeed limits precluded stabilized normal load factors higher than 2.0. No significant differences from those results reported in references 8 and 18, appendix A, were noted during maneuvering stability testing.

AIRCRAFT SYSTEMS FAILURES

Simulated Sudden Engine Failures

30. The response of the test helicopter to simulated sudden engine failures was evaluated at the conditions listed in table 1 with SCAS ON. Engine failure was simulated by rapidly rolling the throttle to the flight-idle position. All flight controls

were held fixed following the simulated power loss until the rotor speed audio warning was heard in the pilot's headset. Collective pitch control was then lowered and aircraft attitude adjusted to stabilized autorotational descent at or near 70 KCAS, the airspeed for minimum rate of descent (Vmin R/D). Representative time histories are presented in figures 53 and 54, appendix E.

31. In level flight the primary cue to loss of power at V_H (130 KCAS) (fig. 53, app E) was a left yaw acceleration followed immediately by a left roll acceleration of lesser magnitude. Maximum yaw rate (10 deg/sec) and maximum roll rate (14 deg/sec) occurred 0.6 second and 1.4 second, respectively, after rolling the throttle to the flight-idle position. Pitch rate was less than 3 deg/sec following the simulated sudden engine failure.

32. Collective delay time at V_H was approximately 1.3 seconds and rotor speed decay rate during the time the collective was held fixed was approximately 25 rpm/sec. Minimum transient rotor speed was 258 rpm and occurred approximately 2.4 seconds after recovery was initiated. Minimum allowable rotor speed for continuous operation (295 rpm) was regained approximately 7.8 seconds after recovery was initiated. Rotor speed recovery rate from minimum transient rotor speed to minimum allowable rotor speed was approximately 10 rpm/sec. Analysis of the data from the level flight buildup to V_H showed small pitch trim changes throughout the range of airspeed tested; a yaw rate of approximately 10 deg/sec at all airspeeds between 80 KCAS and V_H; and a gradual increase in roll rate from 4 deg/sec at 70 KCAS to 14 deg/sec at V_H. Trends in roll rate indicated that roll response to sudden engine failure became more severe with increasing airspeed; however, the roll rates were not as severe for similar conditions as those reported in USAAEFA Final Report No. 74-33 (ref 18, app A). Aircraft response to simulated sudden engine failure at V_H was less severe than the aircraft response previously noted during AH-1 series aircraft evaluations, and is satisfactory.

33. In a maximum power climb the primary cue to loss of power at 73 KCAS (fig. 54, app E) was a left yaw acceleration followed immediately by a left roll acceleration of lesser magnitude. Maximum yaw rate (13 deg/sec) and maximum roll rate (8 deg/sec) occurred 0.7 second and 1.3 seconds, respectively, after rolling the throttle to the flight-idle position. Pitch rate was less than 4 deg/sec following the simulated sudden engine failure.

34. The longest collective delay time at 73 KCAS, the airspeed for maximum rate of climb (V_{max} R/C), was approximately 1.4 seconds. Average rotor speed decay rate during the time the collective was held fixed was 40 rpm/sec. Minimum transient rotor speed was 248 rpm and occurred approximately 2.4 seconds after recovery was initiated. Minimum allowable rotor speed for continuous operation (295 rpm) was attained approximately 7.4 seconds after recovery was initiated. Rotor speed recovery rate from minimum transient rotor speed to minimum continuous rotor speed was approximately 14 rpm/sec. Lowering the collective at 3.0 in./sec resulted in a minimum load factor of 0.4, and no adverse handling qualities were noted during recovery (HQRS 3). Analysis of the data produced during the engine power buildup to $V_{max.}$R/C, progressing from power for level flight to maximum continuous power (50 psi), shows pitch attitude changes essentially the same throughout the range of power tested; a yaw rate gradually increasing from 10 to 13 deg/sec with power addition; and a gradual increase in roll rate from 5 to 8 deg/sec.

Dual Hydraulic Systems Failures

35. Dual hydraulic systems failures were conducted to compare the flying qualities of the YAH-1R with K-747 and B-540 rotor blades installed. Test conditions are shown in table 1. Aircraft reaction to simultaneous dual hydraulic systems failures and pilot cues to the failures were evaluated at trimmed level flight airspeeds of 70, 100, and 122 knots indicated airspeed (KIAS). The aircraft was decelerated from each of these airspeeds in 10-knot increments with hydraulic systems OFF. Handling qualities and control forces at these airspeeds were evaluated by making altitude changes and shallow turns (15-degree bank angle). Following these evaluations, landing approaches were made to determine the pilot's ability to safely land the aircraft following a dual hydraulic systems failure.

36. Helicopter response and pilot cues to simultaneous loss of both hydraulic systems were essentially the same for both rotor systems. Initial aircraft response to the failure was a slight left yaw; a roll oscillation, usually beginning with a right roll; and a change in pedal position. At 122 KIAS the initial roll acceleration was objectionable because the pilot tended to overcontrol the aircraft laterally; however, this condition was improved when airspeed was decreased below 110 KIAS. The pilot first perceived the failure through aircraft response, right pedal pressure, illumination of the master caution light and No. 1 and No. 2 hydraulic systems caution lights, loss of SCAS, and presence of cyclic control feedback.

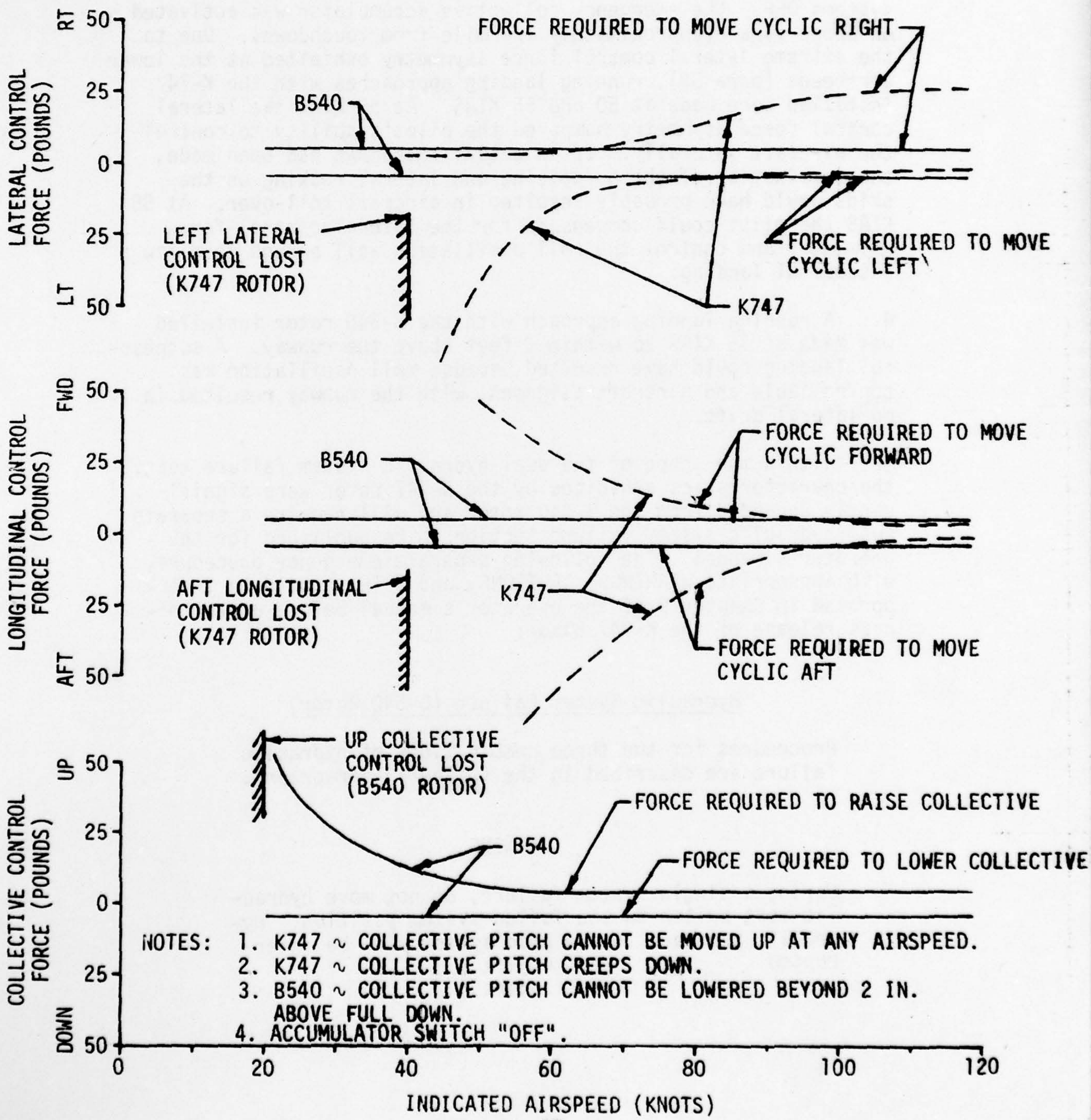
37. With the K-747 blade, collective control was lost immediately at all airspeeds and collective could not be raised or kept from creeping down without the assistance of accumulator pressure. With the B-540 blade, collective control was available without the use of accumulator pressure except for the last 2 inches of full-down collective movement. Since the K-747 blade requires constant use of emergency collective accumulator pressure to control the aircraft, collective motion should be minimized until touchdown so that sufficient accumulator pressure is available to accomplish a landing.

38. Objectionable lateral and longitudinal control force asymmetry existed with the K-747 blade, whereas none was noted with the B-540 blade. Figure D shows control force required to move the aircraft control from a trimmed condition for both rotor blade types. As shown in figure D, the lateral control forces required for adequate roll control with the K-747 blade were 3 pounds left and 23 pounds right at 100 KIAS. Slowing the aircraft to 80 KIAS essentially eliminated this lateral control force asymmetry, and approximately 10 pounds of force (left or right) was required for adequate control. At 60 KIAS, control force asymmetry once again became evident, and at 50 KIAS adequate roll control required 2 pounds of right force and 45 pounds of left force. At 40 KIAS, 55 pounds of left lateral force was insufficient to change lateral stick position, and lateral control of the aircraft was lost. Longitudinally, fore and aft control force symmetry was satisfactory at higher airspeeds but gradually degraded at slower airspeeds. At 40 KIAS, 65 pounds of aft stick force was insufficient to change longitudinal stick position, and longitudinal control of the aircraft was lost. Control force harmony between axes was satisfactory only at 80 KIAS with a control force of approximately 10 pounds required to move the cyclic control in any direction. V_{cruise} with the K-747 blade installed and a dual hydraulic system failure at the condition tested was 80 KIAS. Control force characteristics were acceptable and satisfactory with the B-540 blade installed.

39. The dual hydraulic system failure procedures specified in the operator's manual, which recommends running landings, were qualitatively evaluated for accuracy and adequacy with the B-540 blade. Tests were also conducted with the K-747 blade to see if the same procedures would be applicable. As a build-up to the hydraulic systems failure tests, touchdown landings at various airspeeds with both hydraulic systems functioning and SCAS OFF were made to define SCAS OFF landing characteristics. During these hydraulics ON, SCAS OFF tests, 35 KIAS was found to be the best airspeed for touchdown. At airspeeds greater than 35 KIAS,

FIGURE D
FORCE REQUIRED TO MOVE CONTROLS FROM
TRIM POSITION AT A GIVEN AIRSPEED
WITH BOTH HYDRAULIC BOOST SYSTEMS OFF
YAH-1R USA S/N 70-15936

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	CONFIGURATION
9800	194.2(MID)	.1(RT)	4200	21.0	324	HEAVY TOW



the aircraft tended to porpoise during the landing rollout but the pilot could easily control the aircraft. At airspeeds less than 35 KIAS, the combination of inherent sideslip and roll oscillation required considerable pilot compensation to maintain runway alignment and simultaneous touchdown of both skids.

40. After the build-up tests, shallow-angle landing approaches to within 5 feet of the ground were made with the hydraulic systems OFF. The emergency collective accumulator was activated on short final (approximately 1/4 mile from touchdown). Due to the extreme lateral control force asymmetry exhibited at the lower airspeeds (para 38), running landing approaches with the K-747 installed were made at 50 and 55 KIAS. At 50 KIAS the lateral control force asymmetry hampered the pilot's ability to control the aircraft laterally. If an actual touchdown had been made, the combination of the porpoising and lateral rocking on the skids would have probably resulted in aircraft roll-over. At 55 KIAS the pilot could compensate for the lateral control force asymmetry and control the roll oscillation well enough to allow a successful landing.

41. A running landing approach with the B-540 rotor installed was made at 35 KIAS to within 5 feet above the runway. A successful landing could have resulted because roll oscillation was controllable and aircraft alignment with the runway resulted in no lateral drift.

42. Within the scope of the dual hydraulic system failure test, the characteristics exhibited by the K-747 rotor were significantly degraded from the B-540 rotor and will require a separate dual hydraulic system failure section to be published for the operator's manual. The following separate emergency procedure, with appropriate WARNINGS, CAUTIONS, and NOTES should be incorporated in Chapter 9 of the operator's manual before airworthiness release of the K-747 blade.

<u>Hydraulic System Failure (B-540 Rotor)</u>

Procedures for the three combinations of hydraulic failure are described in the following paragraphs.

WARNING

During a single system failure, do not move hydraulic test switch to the failed system position. Hydraulic pressure to the good system will be interrupted.

CAUTION

Before further flight, the cause of hydraulic failure shall be determined and corrected.

Hydraulic System No. 1 Failure

1. EMER COLL HYD Switch - OFF pilot and gunner.

2. HYD CONT Circuit Breaker - In.

3. SCAS - Disengage YAW channel.

4. WEAPON SIGHT AC Circuit Breaker - Out.

WARNING

Due to the extremely serious nature of a dual hydraulic system failure, the aircraft should be landed at the nearest safe site after experiencing a single hydraulic system failure.

5. Prepare to Land. A running landing is recommended with a touchdown speed of 35 KIAS for the B-540 rotor, terrain permitting.

6. EMER COLL HYD Switch - ON (final approach).

NOTE

Loss of system No. 1 will result in loss of tail rotor boost, the directional control SCAS actuator, and the ability to charge the accumulator. Cyclic and collective control feedback may be evident during abrupt maneuvers.

Hydraulic System No. 2 Failure

1. EMER COLL HYD Switch - OFF pilot and gunner.

2. HYD CONT Circuit Breaker - In.

3. SCAS - Disengage PITCH and ROLL channels.

4. WEAPON SIGHT AC Circuit Breaker - Out.

WARNING

Due to the extremely serious nature of a dual hydraulic system failure, the aircraft should be landed at the nearest safe site after experiencing a single hydraulic system failure.

5. Prepare to Land. A running landing is recommended with a touchdown speed of 35 KIAS for the B-540 rotor, terrain permitting.

6. EMER COLL HYD Switch - ON (final approach).

NOTE

Loss of the No. 2 hydraulic system will result in loss of pitch and roll SCAS actuators. The turret will return to the stow position in elevation; however, it will not stow in azimuth. Cyclic and collective control feedback may be evident during abrupt maneuvers.

Hydraulic System No. 1 and No. 2 Failure

1. EMER COLL HYD Switch - OFF pilot and gunner.

2. HYD CONT Circuit Breaker - In.

3. SCAS - Disengage all channels.

4. WEAPON SIGHT AC Circuit Breaker - Out.

5. Airspeed - Maintain speed where control forces are manageable.

WARNING

With Bell B-540 rotor blades installed on the aircraft, cyclic feedback forces become uncontrollable below 20 KIAS.

CAUTION

To prevent depleting the collective accumulator collective motion must be kept to a minimum. The EMER COLL HYD switch should remain in the OFF position until short final approach except when up collective inputs are necessary.

6. Prepare to Land. A running landing is recommended to a prepared field with a touchdown speed of 35 KIAS for the B-540 rotor, terrain permitting.

7. EMER COLL HYD Switch - CHECK ON (short final approach).

NOTE

Loss of both hydraulic systems will result in loss of the SCAS actuators, cyclic, collective and tail rotor boost, and loss of directional control of the turret. The turret will return to the stow position in elevation; however, it will not stow in azimuth.

Hydraulic System Failure (K-747 Rotor)

Procedures for the three combinations of hydraulic failure are described in the following paragraphs.

WARNING

During a single system failure, do not move hydraulic test switch to the failed system position. Hydraulic pressure to the good system will be interrupted.

CAUTION

Before further flight, the cause of hydraulic failure shall be determined and corrected.

Hydraulic System No. 1 Failure

1. EMER COLL HYD Switch - OFF pilot and gunner.

2. HYD Cont Circuit Breaker - In.

3. SCAS - Disengage YAW channel.

4. WEAPON SIGHT AC Circuit Breaker - Out.

WARNING

Due to the extremely serious nature of a dual hydraulic system failure, the aircraft should be landed at the nearest safe site after experiencing a single hydraulic system failure.

5. Prepare to Land. A running landing is recommended with a touchdown speed of 55 KIAS for the K-747 rotor, terrain permitting.

6. EMER COLL HYD Switch - ON (final approach).

NOTE

Loss of system No. 1 will result in loss of tail rotor boost, the directional control SCAS actuator, and the ability to charge the accumulator. Cyclic and collective control feedback may be evident during abrupt maneuvers.

Hydraulic System No. 2 Failure

1. EMER COLL HYD Switch - OFF pilot and gunner.

2. HYD CONT Circuit Breaker - In.

3. SCAS - Disengage PITCH and ROLL channels.

4. WEAPON SIGHT AC Circuit Breaker - Out.

WARNING

Due to the extremely serious nature of a dual hydraulic system failure, the aircraft should be landed at the nearest safe site after experiencing a single hydraulic system failure.

5. Prepare to Land. A running landing is recommended with a touchdown speed of 55 KIAS for the K-747 rotor, terrain permitting.

6. EMER COLL HYD Switch - ON (final approach).

NOTE

Loss of the No. 2 hydraulic system will result in loss of pitch and roll SCAS actuators. The turret will return to the stow position in elevation; however, it will not stow in azimuth. Cyclic and collective control feedback may be evident during abrupt maneuvers.

Hydraulic System No. 1 and No. 2 Failure

NOTE
(K-747 Rotor Only)

Following loss of both hydraulic systems the collective cannot be raised without the use of emergency collective and accumulator pressure; the collective will creep down in flight; lateral and longitudinal control forces are not equal left and right or fore and aft at any airspeed except 80 KIAS; and the aircraft cannot be controlled at airspeeds below 50 KIAS.

1. EMER COLL HYD Switch - OFF pilot and gunner.

2. HYD CONT Circuit Breaker - In.

3. SCAS - Disengage all channels.

4. WEAPON SIGHT AC Circuit Breaker - Out.

5. Airspeed - Maintain speed where control forces are manageable (suggest 80 KIAS).

WARNING

With Kaman K-747 rotor blades installed on the aircraft, cyclic feedback forces become uncontrollable below 40 KIAS.

6. EMER COLL HYD Switch - ON (as necessary to control collective).

CAUTION

To prevent depleting the collective accumulator collective motion must be kept to a minimum. The EMER COLL HYD switch should remain in the off position until short final approach except when up collective inputs are necessary.

7. Prepare to Land. A running landing is recommended to a prepared field with a touchdown speed of 55 KIAS for the K-747 rotor, terrain permitting.

8. EMER COLL HYD Switch - CHECK ON (short final approach).

NOTE

Loss of both hydraulic systems will result in loss of the SCAS actuators, cyclic, collective and tail rotor boost, and loss of directional control of the turret. The turret will return to the stow position in elevation; however, it will not stow in azimuth.

MISCELLANEOUS ENGINEERING TESTS

Vibration Characteristics

43. Vibration characteristics were qualitatively and quantitatively evaluated throughout the test program. Vibration data were gathered simultaneously with data from all other tests. Nine accelerometers were installed in the test aircraft at the locations shown in table 1, appendix C. Representative vibration data obtained during level flight are presented in figures 55 through 63, appendix E.

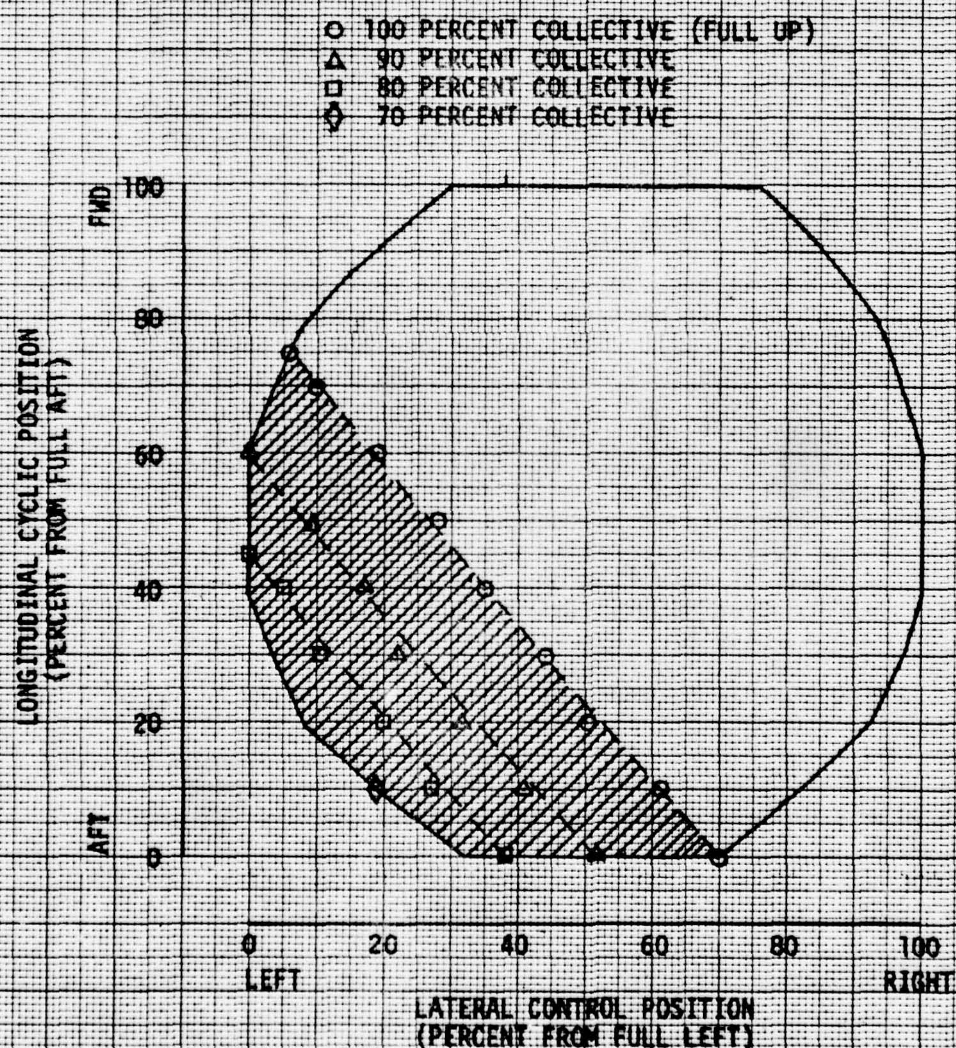
44. In general, the vibration level of the test aircraft was unaffected by the change from B-540 rotor blades to K-747 rotor blades. Vibration levels were representative of those measured during USAAVNTA Project No. 66-06, (ref 19, app A). At no time during these tests were the limitations set by paragraph 3.7.1b. of Mil-H-8501A exceeded with either the B-540 or K-747 blades installed. Within the scope of these tests, the vibration level of the YAH-1R helicopter was unchanged by the use of the K-747 rotor blade, and is satisfactory.

Main Rotor Blade/Pylon Fairing Interference

45. Under static conditions, tests indicated that the K-747 blade could contact the aft portion of the transmission fairing assembly (P/N 209-060-807-11). The K-747 blade has a chord of 3.0 feet as opposed to the B-540 blade which has a chord of 2.25 feet. Blade contact under static conditions occurred when the main rotor was at the full aft teetering angle and at various control positions. Figure E shows the control positions which resulted in blade/fairing contact under static conditions. The greatest area of contact (photo A) occurred when the cyclic control was at the full left position and collective control was full-up. As a result of this finding, for test purposes a section of the standard transmission fairing assembly was removed and replaced with a frangible styrofoam material. The size and shape of the modified fairing (photo B) was identical to the original. During the flying phase of this program, blade contact with the fairing assembly did not occur. AVSCOM directed KAC to investigate the rotor blade/pylon fairing interference problem at the contractor facilities. The results of KAC testing showed that it is highly unlikely the K-747 blade would hit the fairing while the blades are rotating.

FIGURE E
K747 BLADE/FUSELAGE INTERFERENCE
YAH-1R USA S/N 70-15936

NOTES:
1. ROTORS STATIC.
2. MAXIMUM FLAPPING (12.25 DEGREES).
3. NO BLADE BENDING.
4. DIRECTIONAL CONTROL CENTERED.
5. BLADE AZIMUTH APPROXIMATELY 15 DEGREES RIGHT OF TAIL.
6. SHADED AREA REPRESENTS K747/FUSELAGE CONTACT.



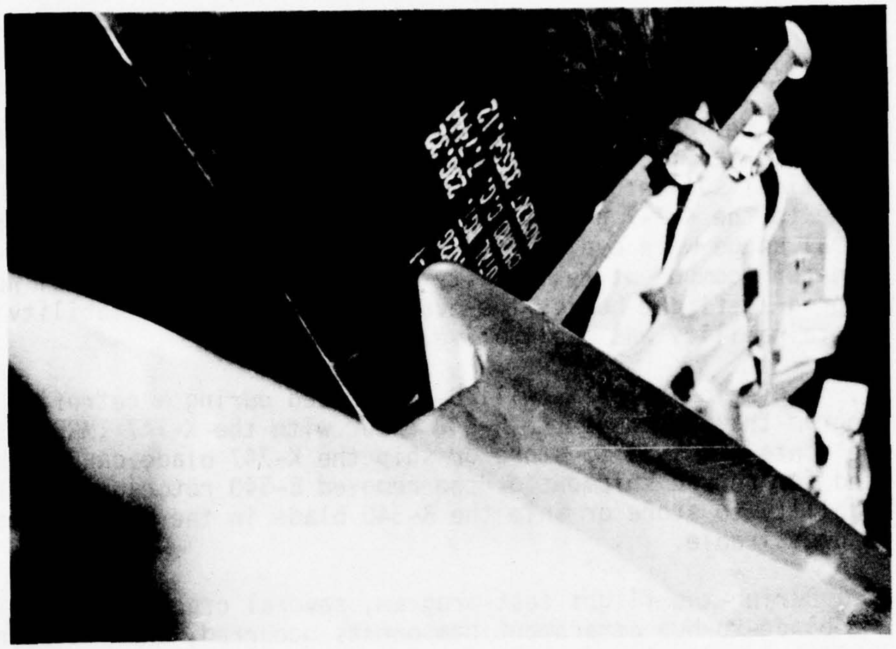


Photo A. Contact with Full-Left Cyclic and Full-Up Collective Control.

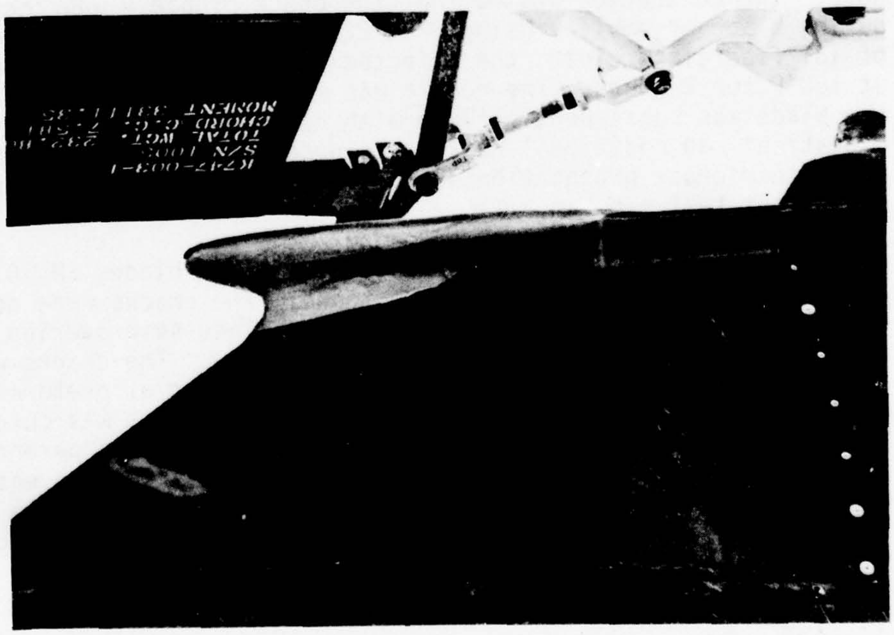


Photo B. Modified Transmission Fairing.

Reliability and Maintainability

46. The reliability and maintainability of the K-747 rotor system was evaluated throughout the conduct of the flight test program. Logistical support equipment, ease of changing from the B-540 blade to the K-747 blade, and serviceability of the blade through normal usage were evaluated. Since the opportunity to observe long-term component reliability was limited by the minimal number of program flight hours, the evaluation of blade reliability and maintainability was qualitative.

47. Logistics problems will be increased during a retrofit program that replaces the B-540 rotor with the K-747 IMRB because the container used to store or ship the K-747 blade cannot be used for return shipment of the removed B-540 rotor blade. The inability to store or ship the B-540 blade in the K-747 container is undesirable.

48. During the flight test program, several cracks in the blade and blade-to-hub attachment components occurred, and adequate published criteria to evaluate the severity of these cracks did not exist. Photo C shows a 3/4-inch crack noted during post-flight blade inspection of the tip of K-747 blade SN 1005. The crack was located aft of the metal tip cap in the composite material and appeared to have originated from a small tooling hole. The contractor stated that the crack probably was incurred during blade assembly. Using EPON 828 epoxy resin and two layers of 181 fiberglass cloth, the affected area was repaired and cured at 160°F for 2 hours. The repair was made by the contractor and the blade was subsequently flown with no noticeable increase in vibration. No additional repair was necessary to the blade and no further crack propagation was noticed during the remainder of the flight test program.

49. Two chordwise cracks, one in each of K-747 blades SN 1013 and 1014 at blade station 88, were found. The cracks were noted upon initial installation and were due to blade skin overlap separation as a result of a manufacturing flaw. The cracks were repaired using EPON 828 epoxy resin and one layer of preformed blade skin sent from the factory. The affected area was cured and the blades subsequently installed and flown. No apparent performance degradation resulted from these repairs. The ease of repair of cracks and other imperfections or damage caused to the K-747 blades and the minimal down time required to effect such repairs is an enhancing characteristic.

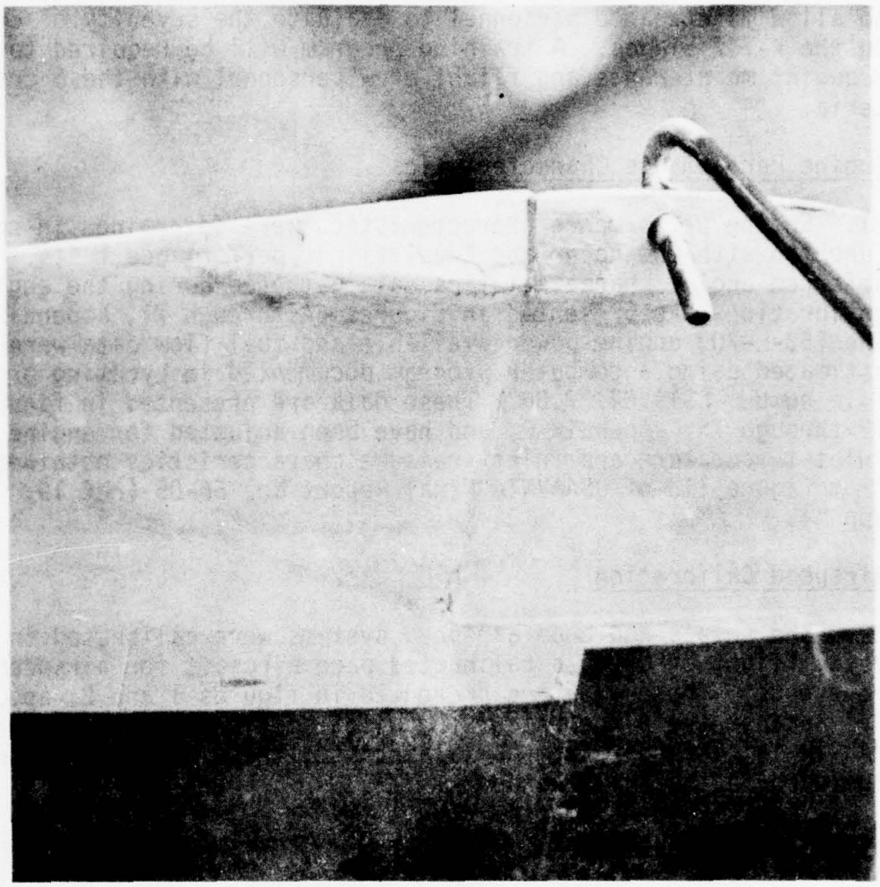


Photo C. Crack Noted at Tip of K-747 Blade SN 1005.

50. Certain types of cracks can be tolerated, easily repaired, and flown with IMRB blades, whereas similar cracks in metal blades would be cause for grounding. Criteria must be published to allow maintenance personnel to evaluate the severity of cracks in the K-747 blades. A training program will be required to acquaint maintenance and flight crew personnel with these criteria.

Engine Performance Characteristics

51. Engine performance characteristics were determined in conjunction with the hover and level flight performance tests. Referred engine characteristics data gathered during the engine calibrations are presented in figures 64 through 71, appendix E. The T53-L-703 engine power available and fuel flow data were estimated using a computer program documented in Lycoming program file number LS19.04.32.00. These data are presented in figures 72 through 75, appendix E, and have been adjusted for engine inlet temperature and inlet pressure characteristics obtained from figure 113 of USAAVNTA Final Report No. 66-06 (ref 19, app A).

Airspeed Calibration

52. The ship's and boom airspeed systems were calibrated in level flight by using a calibrated pace aircraft for airspeed reference. These data are presented in figures 1 and 2, appendix C. Because the placement of the pitot-static systems on the YAH-1R is different from AH-1S aircraft, these data should not be included in the AH-1S handbook.

Acoustical Evaluation

53. A quantitative acoustical evaluation of the YAH-1R with K-747 blade was planned but was not accomplished due to time and resource restraints. Qualitatively, the noise caused by the rotation of the K-747 blades appeared to be somewhat less than that from the B-540 blades. This was noted both in the cockpit by the flight crew and on the ground by maintenance and engineering personnel. It is recommended that a quantitative acoustical evaluation be accomplished on AH-1S aircraft equipped with K-747 blades.

CONCLUSIONS

54. The YAH-1R helicopter with K-747 blade installed exhibits performance improvements in hover, climb, and portions of the level flight envelope. Limited handling qualities tests showed no changes; however, flight characteristics following dual hydraulic system failure were significantly degraded. A separate pilot standardization program for the AH-1 series with the K-747 blades installed is not considered necessary.

55. Specific conclusions are as follows:

a. Maximum gross weight for OGE hover was improved 3.5 percent, but failed to meet the desired 6 percent increase in OGE hover gross weight of the RFP or the specified 8.7 percent increase of the detail specification (para 11).

b. The climb performance of the aircraft was improved with installation of the K-747 blade (para 14).

c. The change in level flight performance of the YAH-1R caused by the installation of the K-747 blade varied with C_T and airspeed (para 18).

d. Airspeeds for minimum rate of descent and maximum glide distance for the K-747 blade were 70 and 98 KCAS, respectively (para 22).

e. Current handbook procedures for safely landing the YAH-1R with dual hydraulic system failures are not appropriate for the K-747 rotor blade (para 42).

f. Vibration levels in the YAH-1R were essentially unchanged with the K-747 blade installed (para 44).

g. The inability to store or ship the B-540 blade in the K-747 container is undesirable (para 47).

h. During the flight test program, several cracks in the blade and blade-to-hub attachment were found and adequate published criteria to determine the severity of and repair these cracks did not exist (para 48).

i. The ease of repair of cracks and other imperfections or damage caused to the K-747 blade and the minimal down time required to effect such repairs is an enhancing characteristic (para 49).

j. No deficiencies or shortcomings were identified during this evaluation.

RECOMMENDATIONS

56. Further autorotational descent performance testing should be conducted on the AH-1S with K-747 rotor blade to obtain data for the AH-1S operator's manual (para 22).

57. The separate emergency procedure, Hydraulic System Failure (K-747 Rotor), with appropriate WARNINGS, CAUTIONS, and NOTES should be incorporated in chapter 9 of the operator's manual (para 42).

58. Publish adequate criteria to allow maintenance personnel to determine severity of cracks in the K-747 blades (para 50).

59. A single standardization program for the AH-1S with either the B-540 or K-747 blades installed should be adopted.

60. Institute a training program for pilots and maintenance personnel on the K-747 blade to cover all maintenance requirements for the blades, accenting what types of cracks can be tolerated, repaired, and flown with safety (para 50).

APPENDIX A. REFERENCES

1. Final Report, USAAEFA, Project 76-07, *Army Preliminary Evaluation, Improved Main Rotor Blade Installed on the YAH-1R Helicopter*, April 1977.

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18. Final Report, USAAEFA, Project 74-33, *Army Preliminary Evaluation, YAH-1R Improved Cobra Agility and Maneuverability Helicopter*, May 1975.

19. Final Report, US Army Aviation Test Activity (USAAVNTA), Project No. 66-06, *Engineering Flight Test AH-1G Helicopter (HUEYCOBRA), Phase D, Part 2, Performance*, April 1970.

20. Army Regulation AR 310-25, Dictionary of United States Army Terms, 15 September 1975.

21. Specification, No. 104.43, Lycoming Division of AVCO Corporation, Model Specification T53-L-73 (LTCIK-4G) Turboshaft Engine, 1 May 1974.

APPENDIX B. AIRCRAFT DESCRIPTION

FUSELAGE

1. The YAH-1R fuselage is idential in outward appearance and dimensions to the AH-1G helicopter. Internal modifications to strengthen the fuselage structure to accept the increased gross weight, power, and tail rotor power include strenghtened transmission mounts and associated structure and strengthened tail boom. AH-1S wings were installed on the YAH-1R to accommodate simulated TOW launchers. External dimensions of the AH-1S wing are not changed from the AH-1G except that the hard points for jacking are located at fuselage station (FS) 200.55 instead of FS 197.85. The nose section of the YAH-1R was not modified with the TOW sighting system.

ENGINE

2. The T53-L-703 engine installed in the YAH-1R helicopter is a growth version of the T53-L-13B engine. The T53-L-703 is a turboshaft engine with a two-stage axial flow free power turbine; two-stage axial flow turbine driving a combination five-stage axial, one-stage centrifugal compressor having a nominal 8:1 compression ratio at the thermodynamic limit and incorporating compressor interstage air bleed; variable inlet guide vanes; and an external annular atomizing combuster. A 3.2105:1 reduction gear housed in the air inlet housing reduces power turbine speed to output shaft speed (nominally 6600 rpm output shaft speed). The engine reduction gearbox is limited to 1175 ft-lb torque for 30 minutes and 1110 ft-lb torque for continuous usage. The engine achieves this power growth over the T53-L-13B engine through increased gas producer speed and increased operating temperatures made possible by improving the air cooling of the first-stage gas producer nozzle and by incorporating air-cooled blades in the first-stage turbine. New materials are employed in the second-stage gas producer and power turbines. A T_7 interstage turbine temperature sensor harness has been incorporated for measurement of interstage turbine temperature, giving a more accurate indication of engine internal temperature than the T_9 temperature (exhaust gas) sensed in the T53-L-13B engine. T_7 temperature is displayed in the cockpit in place of T_9. This is noticeable in the higher temperature limit on the gage and in the shorter temperature rise time on starting the engine.

TRANSMISSION AND TAIL ROTOR DRIVE

3. An uprated transmission and tail rotor drive system is installed in the YAH-1R helicopter. These systems have the following limits:

a. Transmission:

(1) 1290 horsepower for 30 minutes.

(2) 1134 maximum continuous horsepower.

b. Tail rotor drive:

(1) 260 horsepower for 4-second transient limit.

(2) 187 horsepower maximum continuous power.

ENGINE OIL COOLER

4. The cooling capacity of the engine oil cooler has been increased by enlarging the bleed air orifice which drives the turbine oil cooler fan, allowing higher cooling fan speed and cooling air mass flow.

CONTROL SYSTEM

5. The control system of the YAH-1R is basically the same as the AH-1G; however, two new features have been incorporated. The cable controls in the AH-1G antitorque system have been replaced by push-pull tubes. A collective control rate limiter which limits the rate of collective control movement to 115 percent of full throw in 1 second has been incorporated.

MAIN ROTOR BLADES

6. During this test two sets of rotor blades were evaluated, the standard B-540 rotor blades manufactured by Bell Helicopter Textron and the K-747 rotor blades manufactured by Kaman Aerospace Corporation. The B-540 blades are of all-metal construction and utilize a symmetrical constant chord airfoil section with a 2024 T4 aluminum spar and nomex honeycomb core. The K-747 blades utilize a multicell filament-wound fiberglass spar, a nomex core afterbody, and a Kevlar trailing edge spline, all

enclosed by fiberglass skin. At the inboard end, cheekplates carry blade loads to an aluminum adapter which attaches the blade to the current AH-1 rotor hub using the standard hub pin. The K-747 rotor system has the same radius and essentially the same solidity as the standard B-540 rotor (.0625 as compared with .0651 for the B-540), although the blade planform is changed. The blade twist is increased and a nonsymmetrical airfoil shape is employed. The blade weight and stiffness distribution for the K-747 were designed to match the B-540.

7. The K-747 blade airfoil shape is based on a family of airfoils developed by Boeing Vertol. Planform dimensions are shown in figure 1 and a typical cross-section is shown in figure 2. The outer 15 percent of the K-747 blade is tapered in thickness and planform with a tip chord of .83 feet. The airfoil design varies from blade tip to blade root as follows:

γ/R (Blade Radius Sta)	Airfoil Design
From tip to .85	8% thick Boeing Vertol VR-8
From .85 to .67	Linear transition at 12% thick VR-7
From .67 to .25	12% thick Boeing Vertol VR-7
From .25 to .18	Gradual buildup to 25% by cheekplates

The current AH-1Q hub with hub pin located at $\gamma/R = .15$ is retained. There is an attachment adapter fitting and drag brace between the pin and the end of the blade.

PRINCIPAL DIMENSIONS

8. The principal dimensions and general data concerning the YAH-1R helicopter are as follows:

Overall Dimensions

Length, rotor turning	52 ft, 11 in.
Width, rotor turning	44 ft
Height, tail rotor vertical	13 ft, 9.5 in.
Length, rotor removed	45 ft, 2.2. in.

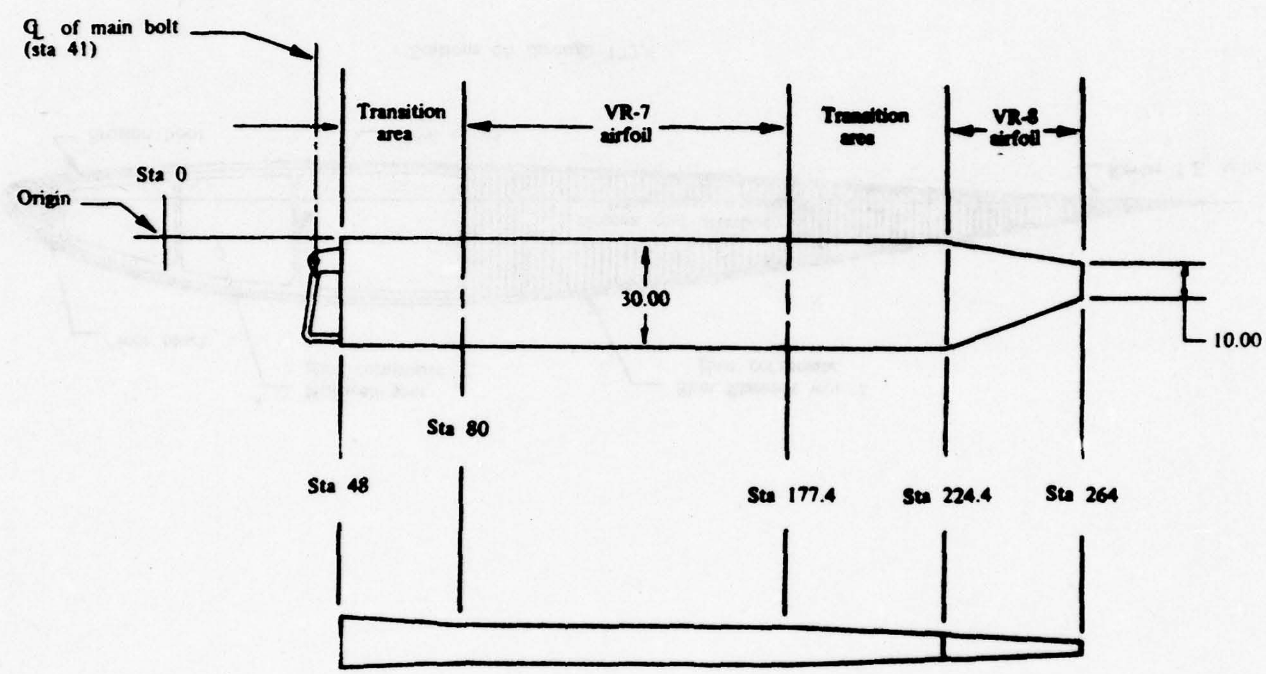
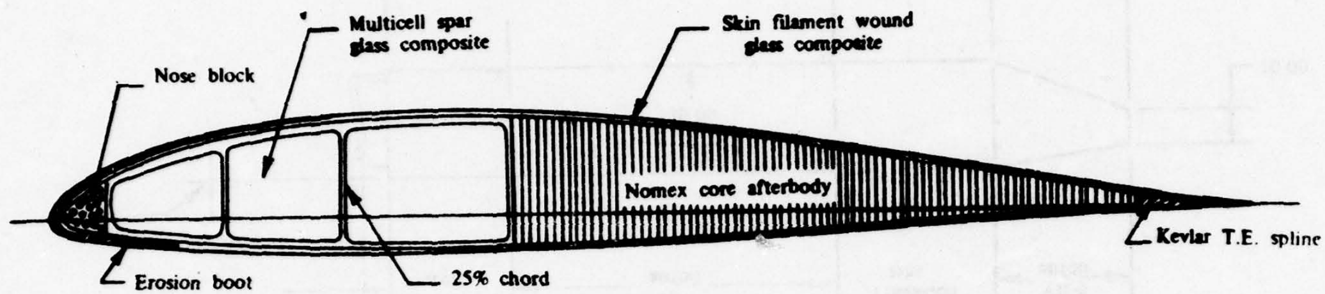


Figure 1. K-747 Blade Configuration.



Stations 66 through 177.4

Figure 2. K-747 Blade Cross-Section Structural Arrangement.

Main Rotor	K-747	B-540
Diameter	44 ft	44 ft
Disc area	1520.5 ft^2	1520.5 ft^2
Solidity	0.0625	0.0651
Number of blades	2	2
Blade chord	See fig. 1	2.25 ft, constant
Blade twist	-0.556 deg/ft	-0.455 deg/ft
Airfoil	See para 2	9.33 percent thickness, special symmetrical section

Tail Rotor	
Diameter	8 ft, 6 in.
Disc area	56.75 ft^2
Solidity	0.1436
Number of blades	2
Blade chord, constant	11.5 in.
Blade twist	0.0 deg/ft
Airfoil	NACA 0018 at blade root, changing linearly to special cambered section of 8.27 percent of tip

Fuselage	
Length, rotor removed	45 ft, 2.2 in.
Height:	
To tip of tail fin	10 ft, 4 in.
Ground to top of mast	11 ft, 7 in.
Ground to top of transmission fairing	10 ft, 2 in.
Ground to bottom of chin turret	1 ft, 2 in.
Width:	
Fuselage only	3 ft
Wing span	10 ft, 8.24 in.
Engine cowling	3 ft, 6 in.
Skid gear tread	7 ft, 4 in.
Elevator:	
Span	6 ft, 2 in.
Area	25.2 ft^2
Airfoil	Inverted Clark Y

Vertical fin:	
Area	18.5 ft^2
Airfoil	Special cambered
Height	5 ft, 6 in.
Wing:	
Span	10 ft, 8.24 in.
Area	27.8 ft^2
Incidence	14.0 deg
Airfoil (root)	NACA 0030
Airfoil (tip)	NACA 0024

10. A flight control rigging check performed in accordance with procedures outlined in TM 55-1520234-20 demonstrated the cyclic, collective, and directional controls were within prescribed limits. The swashplate angles which were measured with respect to aircraft axes and tail rotor blade pitch angles were as follows:

Swashplate Angles

Control position:	Lateral angle:	Longitudinal angle:
Neutral	1.5 deg left, down	1 deg nose-up
Full forward	5 deg right, down	10 deg nose-down
Full aft	5 deg left, down	12.5 deg nose-up
Full right	7 deg right, down	4.5 deg nose-up
Full left	7.5 deg left, down	3.5 deg nose-down

Tail Rotor Blade Pitch Angles

Pedal position:	Blade angle:
Full left	19.9 deg
Full right	-11.0 deg

WEIGHT AND BALANCE

11. The aircraft weight, longitudinal cg location, and lateral cg location were determined prior to testing, and checked periodically throughout the tests. A fuel cell calibration was also performed prior to testing. All weighings were accomplished with instrumentation installed and without external stores or chin turret weapons installed. The TOW missile pods were ballasted as necessary to achieve desired takeoff gross weights. Tables 1 and 2 show typical takeoff loadings to achieve aft and forward cg's, respectively.

Table 1. Aircraft Loading for Aft Center of Gravity.[1]

Item		Weight (lb)	Longitudinal Center of Gravity (FS)
Basic aircraft[2]		6339	204.6
Fuel[3]		1703	199.4
Oil		26	234.6
Pilot		191	135
Copilot		185	83
Outboard external stores[4]		1068	201.8
Ballast	Tail light	50	472
	Tail boom	50	305
	Aft batt. compt.	100	283
	Pilot station[5]	120	135
	Copilot parachute	20	83
	Turret	150	76
	Fwd batt. compt.	0	40
TOTAL		10002	199.6

1Lateral cg (BL) = 0.1 right
2Includes instrumentation with aircraft battery located in forward compartment FS 40.
3258 gallons at specific weight of 6.6 lb/gallon.
4TOW missile racks on the outboard stores.
5100 pound removable ballast plus 20 pound parachute.

Table 2. Aircraft Loading for Forward Center of Gravity.[1]

Item		Weight (lb)	Longitudinal Center of Gravity (FS)
Basic aircraft[2]		6339	204.6
Fuel[3]		1703	199.4
Oil		26	234.6
Pilot		191	135
Copilot		185	83
Outboard external stores[4]		1068	201.8
Ballast	Tail light	50	472
	Tail boom	50	305
	Aft Batt. compt.	100	238
	Pilot station[5]	120	135
	Copilot parachute	20	83
	Turret	300	76
	Fwd batt. compt.	150	40
TOTAL		10302	195.4

[1]Lateral cg (BL) = 0.1 inch right.
[2]Includes instrumentation with aircraft battery located in forward compartment FS 40.
[3]258 gallons at specific weight of 6.6 lb/gallon.
[4]TOW missile racks on the outboard stores.
[5]100 pounds removable ballast plus 20-pound parachute.

12. The fuel loading for each test flight was determined prior to engine start and following engine shutdown by using a calibrated external sight gage to determine fuel volume and by measuring specific gravity. Fuel used in flight was recorded by a sensitive fuel-used system and verified with the pre- and post-flight sight gage readings.

APPENDIX C. INSTRUMENTATION

1. The test instrumentation system was designed, calibrated, installed, and maintained by USAAEFA. Digital and analog data were obtained from calibrated instrumentation and were recorded on magnetic tape and/or displayed in the cockpit. The digital instrumentation system consisted of various transducers, signal conditioning units, an eight-bit PCM encoder, and an Ampex AR 700 tape recorder. The digital data were also telemetered to a ground station for in-flight monitoring. Time correlation was accomplished with a pilot/engineer event switch and on-board recorded and displayed Inter Range Instrumentation Group (IRIG)B time. Analog data were recorded on two separate tracks of the AR 700 recorder through the use of two voltage control oscillator (VCO) chassis of 6 VCO's each. Various specialized sensitive indicators displayed data to the pilot and engineer on board the aircraft continuously during the flight. A boom was mounted on the nose of the aircraft with the following sensors: swiveling pitot-static head, sideslip vane, angle-of-attack vane, and total-temperature sensor.

2. Calibrated cockpit monitored parameters and special equipment are listed below.

<u>Pilot Station</u>

Airspeed (boom)
Altitude (boom)
Altitude (radar)
Rate of climb (ship's system)
Rotor speed
Engine torque
Measured gas temperature
Gas generator speed
Control position:
- Longitudinal
- Lateral
- Directional
- Collective

Cg normal acceleration
Angle of sideslip
Outside air temperature (ship's system)
Event switch

Copilot/Engineer Station

Event switch
Control fixture
Airspeed (boom)
Altitude (boom)
Rate of climb (ship's system)
Rotor speed
Engine torque
Measured gas temperature
Gas generator speed
Outside air temperature
Attitude gyro (ship's system)
Fuel used (totalizer)
Instrumentation control
Time of day
Record counter

3. Parameters recorded on tape were as follows:

PCM Parameters

Time code
Pilot/engineer event
Rotor speed (digital)
Fuel used
Run number
Airspeed
Altitude
Altitude (radar)
Control position:
  Longitudinal
  Lateral
  Directional
  Collective
  Twist grip
Angle of sideslip
Angle of attack
Main rotor speed (analog)
Gas generator speed
Control force:
  Longitudinal
  Lateral
  Directional
Engine speed (N_2)
Pitch attitude
Roll attitude

SCAS actuator position:
- Longitudinal
- Lateral
- Directional

Center-of-gravity acceleration:
- Normal
- Lateral
- Longitudinal

Engine torque pressure
Main rotor shaft torque
Tail rotor shaft torque
Tail rotor blade angle
Measured gas temperature
Fuel flow rate
Total air temperature
Fuel temperature
Pitch rate
Roll rate
Yaw rate
Magnetic heading

FM Parameters

Pilot seat acceleration:
- Vertical
- Lateral
- Longitudinal

Copilot seat acceleration:
- Vertical
- Lateral
- Longitudinal

Instrument panel acceleration:
- Vertical
- Lateral
- Longitudinal

Main rotor shaft index
Main rotor teetering angle
Main rotor pitch link load

4. The location of the vibration transducers is shown in table 1.

5. A contractor height-velocity (H-V) test program and a dual hydraulic boost failure evaluation required the addition of the following instrumentation:

Table 1. Vibration Transducer Locations.

Description	Axis	Fuselage Station	Buttline	Water Line
Pilot seat	Vertical	137.0	3.0	63.5
Pilot seat	Lateral	137.0	3.0	63.5
Pilot seat	Longitudinal	137.0	3.0	63.5
Copilot seat	Vertical	89.2	8.3	53.5
Copilot seat	Lateral	89.2	8.3	53.5
Copilot seat	Longitudinal	89.2	8.3	53.5
Pilot instrument panel	Vertical	112.6	7.0	78.5
Pilot instrument	Lateral	112.6	7.0	78.5
Pilot instrument panel	Longitudinal	112.6	7.0	78.5

H-V Testing

Touchdown indicator
Sink rate radar

Dual Hydraulic Boost Failure

Failure switch indication
Collective stick force

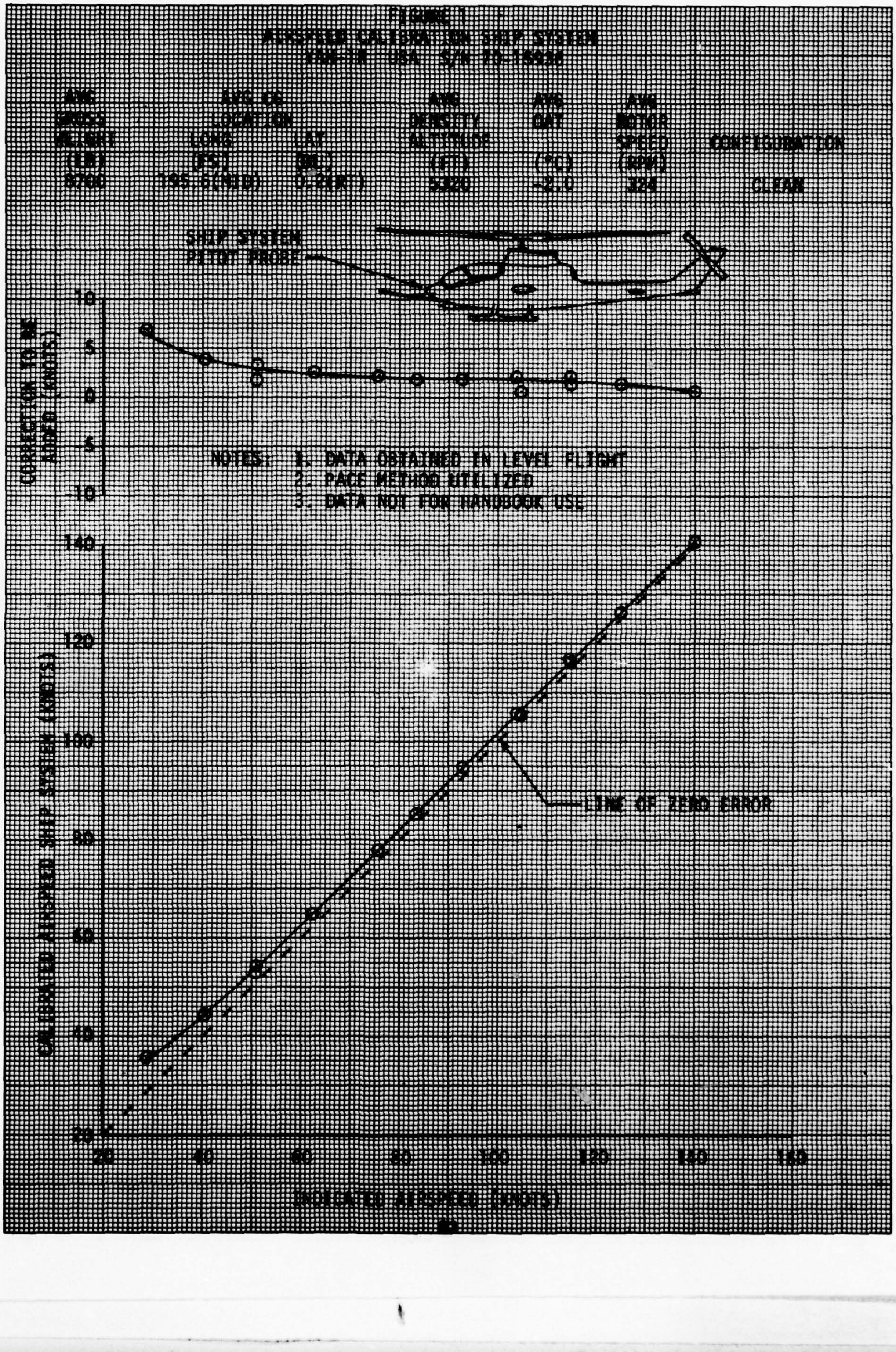
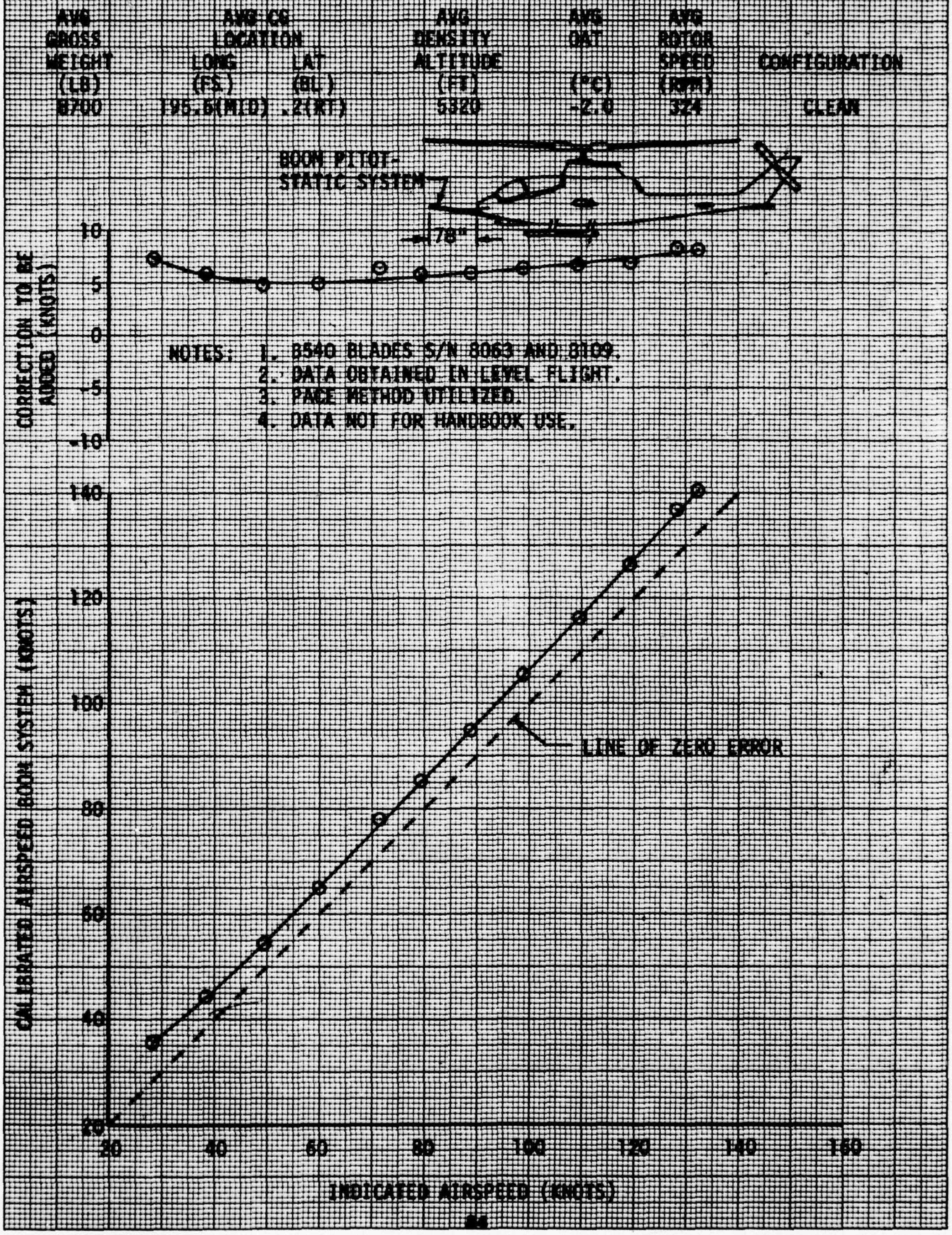


FIGURE 1
AIRSPEED CALIBRATION SHIP SYSTEM
AVG GROSS WEIGHT (LB) 8700
AVG CG LOCATION LONG (FS) 195.6(MID) LAT (BL) 0.2(RT)
AVG DENSITY ALTITUDE (FT) 5320
AVG OAT (°C) -2.0
AVG ROTOR SPEED (RPM) 324
CONFIGURATION CLEAN
SHIP SYSTEM PITOT PROBE
CORRECTION TO BE ADDED (KNOTS)
NOTES: 1. DATA OBTAINED IN LEVEL FLIGHT
2. PACE METHOD UTILIZED
3. DATA NOT FOR HANDBOOK USE
CALIBRATED AIRSPEED SHIP SYSTEM (KNOTS)
LINE OF ZERO ERROR
INDICATED AIRSPEED (KNOTS)

FIGURE 2
AIRSPEED CALIBRATION BOOM SYSTEM
YAH-1R USA S/N 70-15936



APPENDIX D. TEST TECHNIQUES AND DATA ANALYSIS METHODS

TEST TECHNIQUES

1. Conventional test techniques were used in both the performance and handling qualities tests. Detailed descriptions of all test techniques are contained in references 13, 14, and 15, appendix A, except where referred to in the following paragraphs. The Handling Qualities Rating Scale presented in figure 1 was used to augment pilot comments relative to handling qualities. Definitions of deficiencies and shortcomings are as stipulated in Army Regulation 310-25 (ref 20, app A).

DATA ANALYSIS METHODS

Nondimensional Coefficients

2. The nondimensional coefficients listed below were used to generalize the hover, climb, level flight, and autorotational performance test data obtained during this evaluation.

a. Coefficient of power (C_P):

$$C_P = \frac{SHP \times 550}{\rho A(\Omega R)^3} \tag{1}$$

b. Coefficient of thrust (C_T):

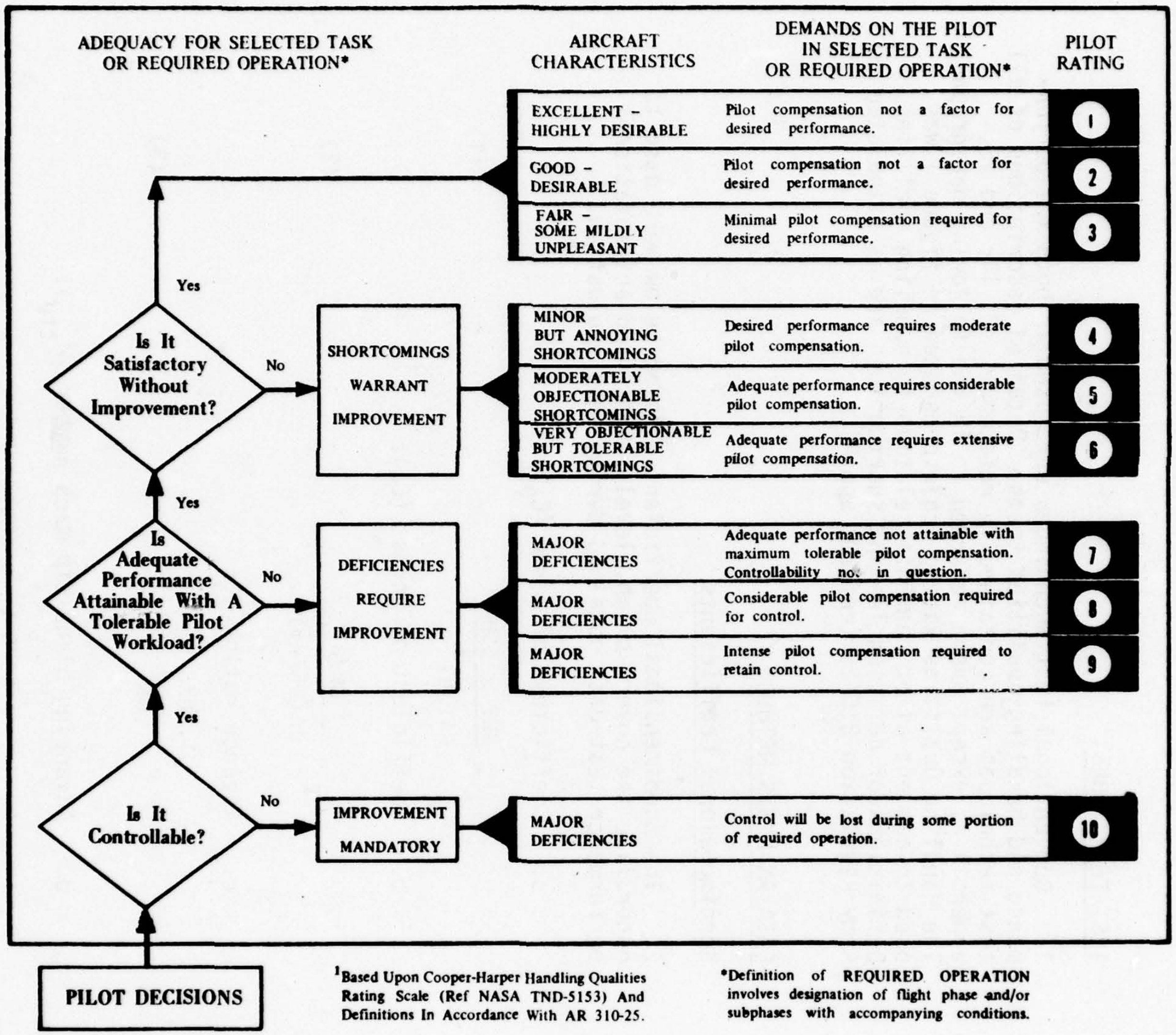
$$C_T = \frac{GW/\delta}{\rho A(\Omega R/\sqrt{\theta})^2} \tag{2}$$

c. Advance ratio (μ):

$$\mu = \frac{1.6878\ V_T}{\Omega R} \tag{3}$$

d. Advancing blade tip mach number (M_{tip}):

$$M_{tip} = \frac{1.6878\ V_T + (\Omega R)}{a} \tag{4}$$



[1]Based Upon Cooper-Harper Handling Qualities Rating Scale (Ref NASA TND-5153) And Definitions In Accordance With AR 310-25.

*Definition of REQUIRED OPERATION involves designation of flight phase and/or subphases with accompanying conditions.

Figure 1. Handling Qualities Rating Scale

Where:

SHP = Engine output shaft horsepower

550 = Conversion factor (ft-lb/sec/shp)

ρ = Air density (slug/ft^3)

A = Main rotor disc area (ft^2)

Ω = Main rotor angular velocity (radian/sec)

R = Main rotor radius (ft)

GW = Aircraft gross weight (lb)

V_T = True airspeed (kt)

a = Speed of sound (ft/sec) = $1116.45\sqrt{\theta}$

1.6878 = Conversion factor (ft/sec/kt)

Values used in the calculation of C_P and C_T for the test aircraft are listed in table 1.

Table 1. Values.[1]

Rotor Speed (rpm)	Ω (Radian/Sec)	$A(\Omega R)$ (Ft^3/Sec)	$A(\Omega R)^2$ (Ft^4/Sec^2)	$A(\Omega R)^3$ (Ft^5/Sec^3)
294	30.79	1.030×10^6	8.472×10^8	4.726×10^{11}
314	32.88	1.100×10^6	7.956×10^8	5.755×10^{11}
324	33.93	1.135×10^6	8.471×10^8	6.324×10^{11}

[1]A = Main rotor disc area = 1520.53 ft^2 and R = main rotor disc area = 22.00 ft.

True airspeed (V_T) was calculated using calibrated airspeed (V_{CAL}) and density ratio (σ) as follows:

$$V_T = \frac{V_{CAL}}{\sqrt{\sigma}} \tag{5}$$

Where:

$\sigma = \rho/.0023769$

Shaft Horsepower Required

3. Engine output shaft torque was determined from the engine manufacturer's differential torque pressure system. The relationship of measured differential torque pressure (psi) to engine output shaft torque (in.-lb) is illustrated in figure 2. The output shp was determined from the engine output shaft torque and rotational speed by the following equation:

$$SHP = \frac{2\pi \times N_P \times Q}{396{,}000} \tag{6}$$

Where:

N_P = Engine output shaft rotational speed (rpm)

Q = Engine output shaft torque (in.-lb)

396,000 = Conversion factor (in.-lb/min/shp)

Tail Rotor Performance

4. During hover performance tests, tail rotor performance parameters were also recorded. Terms in equations 1 and 2, which apply to the main rotor, were replaced by tail rotor parameters for nondimensionalized tail rotor performance. The terms are redefined as:

SHP = Tail rotor shaft horsepower (SHP_{TR})

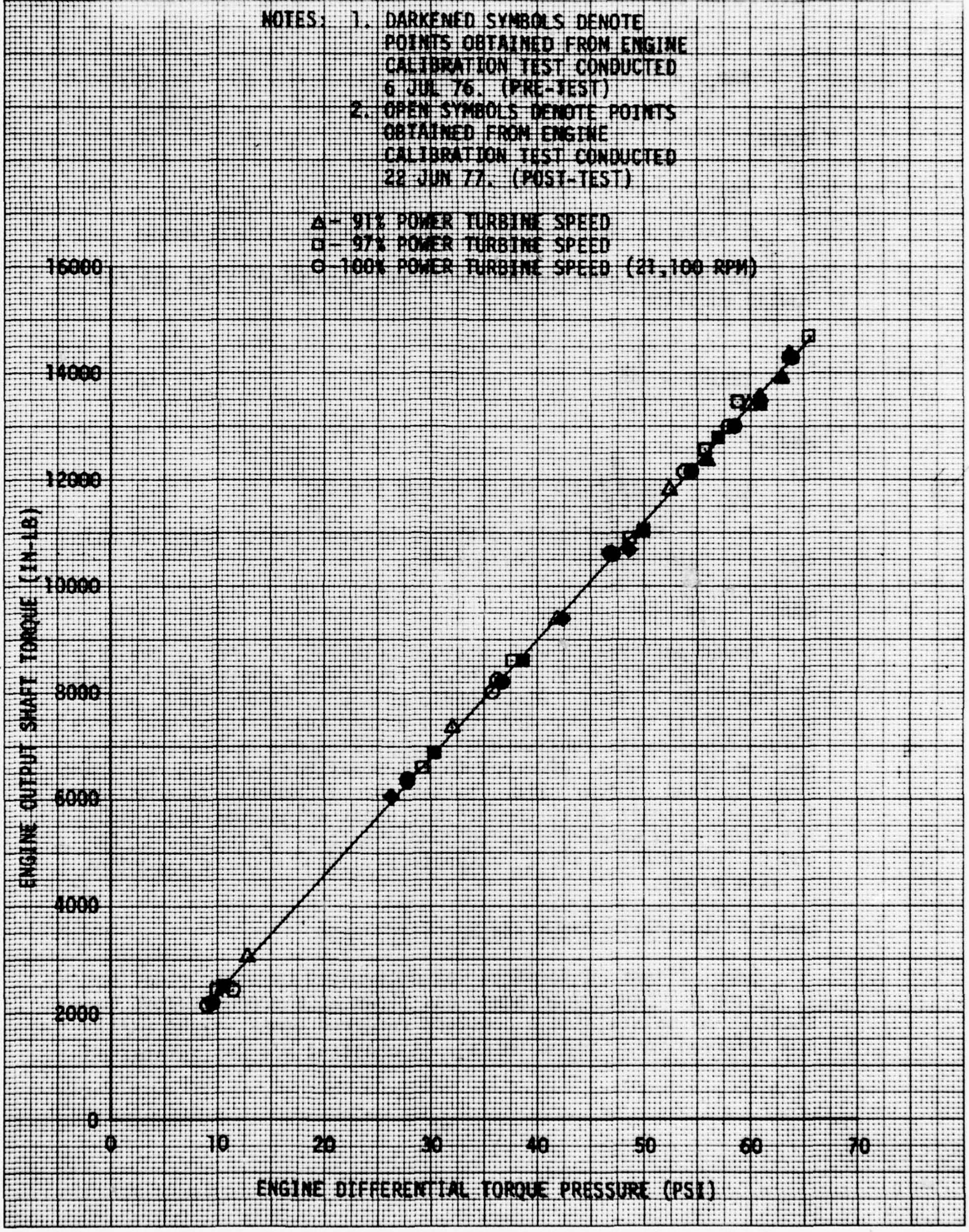
A = Tail disc area (ft^2)

Ω = Tail rotor angular velocity (radian/sec)

R = Tail rotor radius (ft)

GW = Tail rotor thrust (lb)

FIGURE 2
ENGINE TORQUEMETER CALIBRATION
YAH-1R USA S/N 70-15936
LYCOMING ENGINE T53-L-703 S/N LE151242



Tail rotor shp was determined from the following equation:

$$SHP_{TR} = \frac{2\pi(N_P \times 5.10859) \times Q_{TR}}{33,000} \qquad (7)$$

Where:

Q_{TR} = Tail rotor torque (in-lb)

5.10859 = Gear ratio of power turbine to tail rotor

5. Approximate tail rotor thrust was determined from the following equation:

$$THRUST = \frac{Q_{MR}}{l_T} \qquad (8)$$

Where:

Q_{MR} = Main rotor shaft torque (ft-lb)

l_t = Perpendicular distance between center lines of main and tail rotor shafts = 26.72 feet

Hover

6. Hover performance was obtained both IGE and OGE by the free flight hover technique. All hover tests were conducted in winds of less than 3 knots. Atmospheric pressure, temperature, and wind velocity were recorded from a ground weather station. Free flight hover tests consisted of stabilizing the helicopter at a desired height with reference to a premeasured weighted cord hung from the landing gear skid. Ballast was incrementally removed from the aircraft until the minimum gross weight was obtained. All hover data were reduced to nondimensional parameters of C_P and C_T (equations 1 and 2, respectively), and grouped according to skid height.

Level Flight Performance and Specific Range

7. Level flight performance was determined by using equations 1, 2, and 3. Each speed power was flown at a predetermined constant C_T by maintaining a constant referred gross weight (W/δ) and referred rotor speed ($N/\sqrt{\theta}$). A constant W/δ was maintained

by decreasing ambient pressure ratio (δ) as the aircraft gross weight decreased with fuel burnoff. Rotor speed was also varied to maintain a constant $N/\sqrt{\theta}$ as the ambient air temperature varied.

8. Test-day power level flight was corrected to standard-day conditions using equations 9 and 10.

$$SHP_s = SHP_t \left(\frac{P_s}{P_t}\right)\left(\frac{\Omega R_s}{\Omega R_t}\right)^3 \tag{9}$$

$$VT_s = VT_t \left(\frac{\Omega R_s}{\Omega R_t}\right) \tag{10}$$

Where:

t = Test day

s = Standard day

9. Specific range was calculated using level flight performance curves and the specification installed engine fuel flow characteristic.

$$NAMPP = \frac{V_T}{W_f} \tag{11}$$

Where:

NAMPP = Nautical air miles per pound of fuel

V_T = True airspeed (kt)

W_f = Fuel flow (lb/hr)

10. Changes in the equivalent flat plate area (Δf_e) for various aircraft configurations were calculated by the following equation:

$$\Delta fe = \frac{2(\Delta C_P)A}{\mu^3} \tag{12}$$

Sawtooth Climbs and Autorotational Descents

11. A series of sawtooth climbs and autorotational descents were flown to determine power (K_P) and weight (K_W) correction coefficients and autorotational descent performance. The rates of climb and descent (dhp/dt) were determined from the rate of change of boom pressure altitude (H_P) with time, corrected for instrument error, static position error, and altimeter error caused by nonstandard temperature using the following equation:

$$R/C = \left(\frac{dH_P}{dt}\right)\frac{T_t}{T_s} \tag{13}$$

Where:

dhp/dt = Slope of pressure altitude versus time curve at a given pressure altitude (ft/min).

T_t = Test ambient air temperature at the pressure altitude at which the slope is taken (°K)

T_s = Standard ambient air temperature at the pressure altitude which the slope is taken (°K)

12. Climb and descent performance data were reduced to generalized parameters to provide a format for computing performance at any specified climb or descent conditions. The following parameters were used to generalize the climb and descent data:

Generalized power, variation from level flight:

$$\Delta C_{P_{GEN}} = \frac{C_{Pc} - C_{P_L}}{0.707 C_T^{1.5}} \tag{14}$$

Vertical velocity ratio:

$$VVR = \frac{V_v}{\Omega R\sqrt{C_T/2}} \tag{15}$$

Forward velocity ratio:

$$FVR = \frac{V_F}{\Omega R\sqrt{C_T/2}} \tag{16}$$

Where:

C_{P_c} = Climb power coefficient

C_{P_L} = Level flight power coefficient

V_V = Vertical velocity (ft/sec) = $\frac{R/C}{60}$

V_F = Forward velocity (ft/sec) = $1.6878\ V_T \sqrt{1 - \frac{V_V}{1.6878V_T}}$

13. Climb power required for any condition can then be computed from these equations by determining ΔCp_{GEN} as a function of VVR and FVR required for the specific condition. The level flight power coefficient (Cp_L) was obtained from the nondimensional level flight performance curves.

$$C_{P_c} = C_{P_L} + \Delta C_{P_{GEN}} \times 0.707 C_T^{1.5} \qquad (17)$$

14. The climb power correction coefficient (K_p) can be derived as a function of dimensional and nondimensional terms as shown below:

Dimensional:

$$K_P = \frac{\Delta V_V}{\Delta SHP} \times \frac{GW}{550} \qquad (18)$$

Nondimensional:

$$K_P = \frac{\Delta \mu_V}{\Delta C_{P_c}} \times C_T \qquad (19)$$

Where:

μ_V = Vertical advance ratio = $V_V/\Omega R$

15. The weight correction coefficient can be derived as a function of dimensional and nondimensional terms as shown below:

Dimensional:

$$K_W = \frac{\Delta V_v}{\Delta GW} \times \frac{GW^2}{550 \times SHP} \tag{20}$$

Nondimensional:

$$K_W = \frac{\Delta \mu_v}{\Delta C_T} \times \frac{C_T^{\,2}}{C_P} \tag{21}$$

Engine Inlet Characteristics

16. Engine inlet temperature and pressure characteristics were obtained from reference 19, appendix A.

Shaft Horsepower Available and Specification Fuel Flow

17. Shaft horsepower available and specification fuel flow were obtained from Lycoming Engine Model Specification T53-L-703 (LTCIK-4G) No. 104-43 by using computer program file number LS 19.04.32.00 dated 1 May 1974 (ref 21, app A), and the inlet characteristics described in paragraph 16.

18. The referred terms of the engine parameters were used to compare the test engine with the model specification engine. Data on shp, measured gas temperature (T_7), fuel flow, and gas producer speed (N_1) were referred as follows:

a. Referred SHP (RSHP):

$$RSHP = \frac{SHP}{\delta_1 \sqrt{\theta_1}} \tag{22}$$

b. Referred measured gas temperature (RMGT)

$$RMGT = \frac{T_7}{\theta_1} \tag{23}$$

c. Referred fuel flow (RWF)

$$RWF = \frac{W_f}{\delta_1 \sqrt{\theta_1}} \tag{24}$$

d. Referred gas producer speed (RN_1)

$$RN_1 = \frac{N_1}{\sqrt{\theta_1}} \tag{25}$$

Where:

$$\delta_1 = \frac{P_{T_1}}{14.697}$$

$$\theta_1 = \frac{T_1}{288.15}$$

W_f = Engine fuel flow (lb/hr)

P_{T_1} = Engine inlet total pressure (psi)

T_1 = Engine inlet total temperature (°K)

N_1 = Gas producer speed referenced to 25150 rpm (percent)

Pitot-Static Calibration

19. The boom and ship's standard pitot-static system were calibrated by using the pace aircraft method to determine airspeed and altimeter position error. Calibrated airspeed (V_{CAL}) was obtained by correcting indicated airspeed (V_i) for instrument error (ΔV_{ic}) and position error (ΔV_{pc}). Likewise pressure altitude (H_p) was obtained by correcting indicated pressure altitude (H_{p_i}) for instrument error (ΔHp_{ic}) and position error (ΔHp_{pc}). The altimeter position error (ΔHp_{pc}) was calculated using ΔV_{pc} and assuming all errors were introduced at the static port.

$$V_{CAL} = V_i + \Delta V_{ic} + \Delta V_{pc} \tag{26}$$

$$H_P = H_{P_i} + \Delta H_{P_{ic}} + \Delta H_{P_{pc}} \tag{27}$$

$$\Delta H_{P_{pc}} = \Delta V_{pc} \times \frac{58.566}{\sigma_s} \frac{V_{ic}}{a_{SL}} \left[1 + 0.2\left(\frac{V_{ic}}{a_{SL}}\right)^2\right]^{2.5} \tag{28}$$

Where:

σ_s = density ratio at the indicated pressure altitude corrected for instrument error.

V_{ic} = indicated airspeed corrected for instrument error.

a_{SL} = speed of sound at sea level (kt)

c. Referred fuel flow (RWF)

$$RWF = \frac{W_f}{\delta_1 \sqrt{\theta_1}} \tag{24}$$

d. Referred gas producer speed (RN_1)

$$RN_1 = \frac{N_1}{\sqrt{\theta_1}} \tag{25}$$

Where:

$\delta_1 = \dfrac{P_{T_1}}{14.697}$

$\theta_1 = \dfrac{T_1}{288.15}$

W_f = Engine fuel flow (lb/hr)

P_{T_1} = Engine inlet total pressure (psi)

T_1 = Engine inlet total temperature (°K)

N_1 = Gas producer speed referenced to 25150 rpm (percent)

Pitot-Static Calibration

19. The boom and ship's standard pitot-static system were calibrated by using the pace aircraft method to determine airspeed and altimeter position error. Calibrated airspeed (V_{CAL}) was obtained by correcting indicated airspeed (V_i) for instrument error (ΔV_{ic}) and position error (ΔV_{pc}). Likewise pressure altitude (H_p) was obtained by correcting indicated pressure altitude (H_{p_i}) for instrument error (ΔHp_{ic}) and position error (ΔHp_{pc}). The altimeter position error (ΔHp_{pc}) was calculated using ΔV_{pc} and assuming all errors were introduced at the static port.

$$V_{CAL} = V_i + \Delta V_{ic} + \Delta V_{pc} \tag{26}$$

$$H_P = H_{P_i} + \Delta H_{P_{ic}} + \Delta H_{P_{pc}} \tag{27}$$

$$\Delta H_{P_{pc}} = \Delta V_{pc} \times \frac{58.566}{\sigma_s} \frac{V_{ic}}{a_{SL}} \left[1 + 0.2\left(\frac{V_{ic}}{a_{SL}}\right)^2 \right]^{2.5} \tag{28}$$

Where:

σ_s = density ratio at the indicated pressure altitude corrected for instrument error.

V_{ic} = indicated airspeed corrected for instrument error.

a_{SL} = speed of sound at sea level (kt)

APPENDIX E. TEST DATA

INDEX

FIGURE 1
SUMMARY HOVER PERFORMANCE
IN-GROUND EFFECT
YAH-1R USA S/N 70-15936
INTERMEDIATE RATED POWER

NOTES:
1. SHP_{AVAIL} BASED ON FIG. 72.
2. ROTOR SPEED = 324 RPM.
3. B540 BLADES STANDARD DAY DATA NOT AVAILABLE.
4. SKID HEIGHT = 5 FEET.
5. K747 BLADES S/N 1005 AND 1009.
6. SHP_{REQ} BASED ON FIG. 3 AND 4.

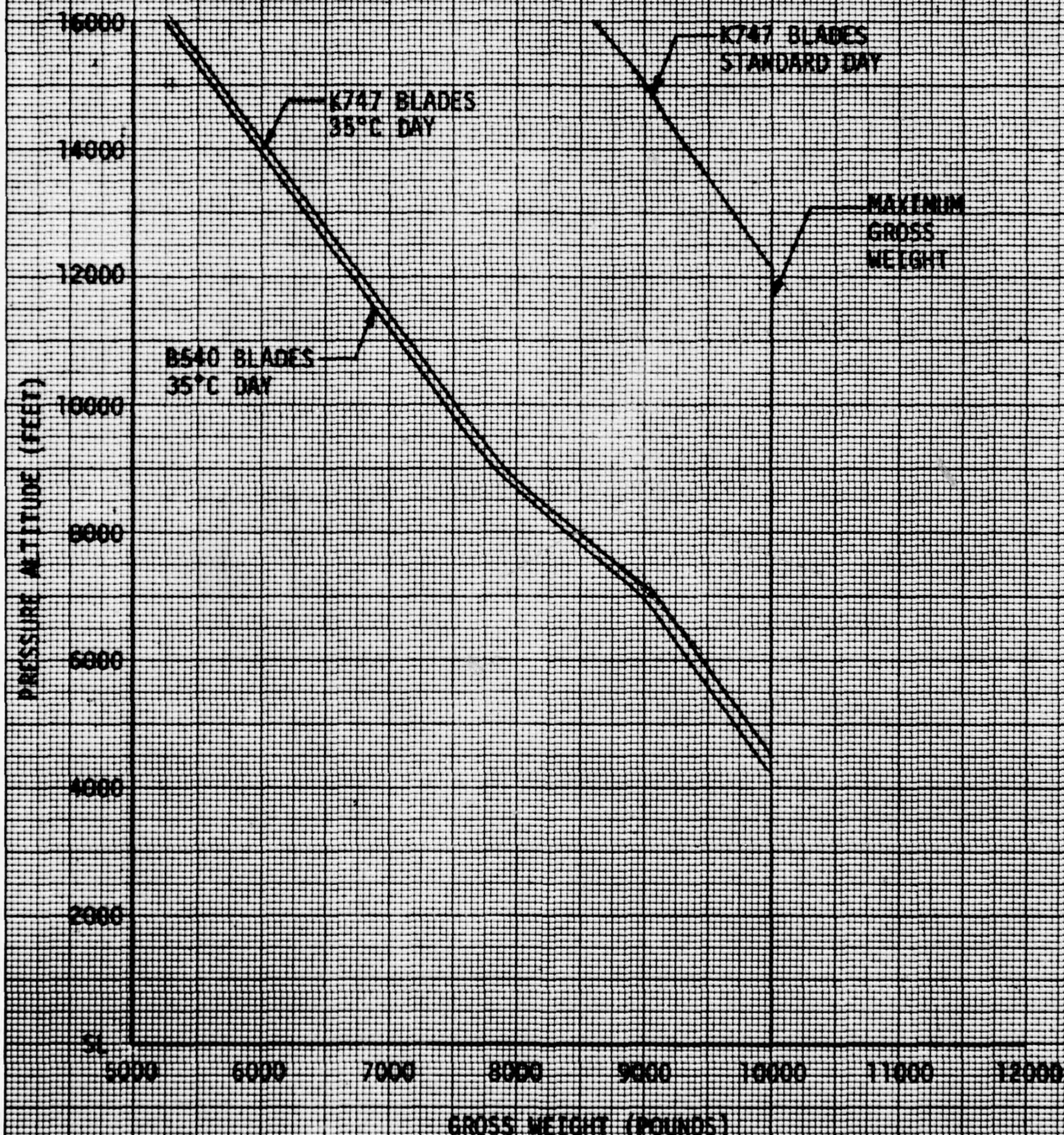


FIGURE 2
SUMMARY HOVER PERFORMANCE
OUT-OF-GROUND EFFECT
YAH-1R USA S/N 70-15936
INTERMEDIATE RATED POWER

NOTES: 1. SHP_{AVAIL} BASED ON FIGURE 72.
2. ROTOR SPEED = 324 RPM
3. SHP_{REQ} BASED ON FIGURES 5 THROUGH 8.
4. SKID HEIGHT = 100 FEET
5. K747 BLADES S/N 1005 AND 1009

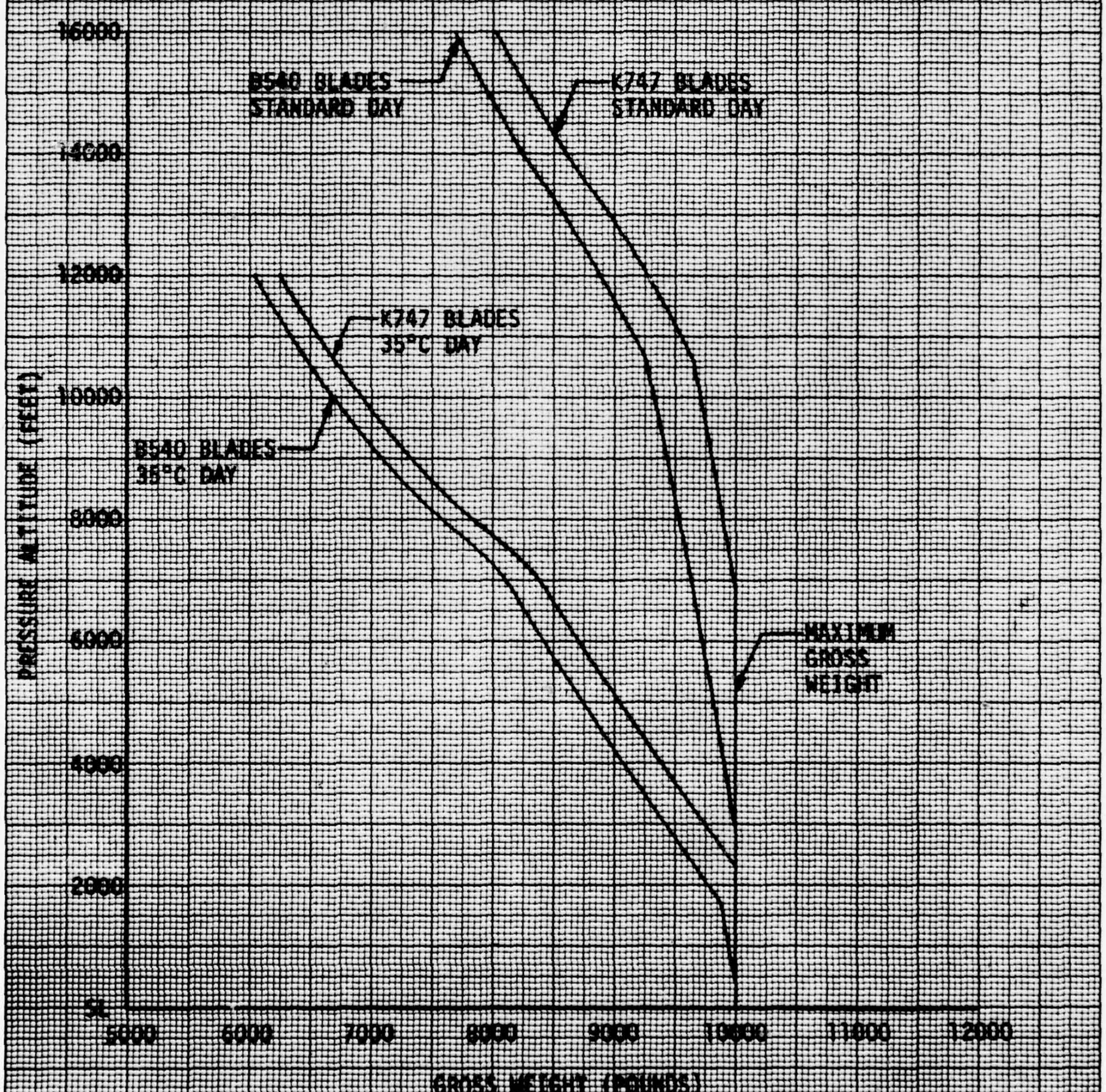


FIGURE 3
IN-GROUND EFFECT NONDIMENSIONAL HOVERING PERFORMANCE
YAH-1R USA S/N 70-15936
ENGINE T53-L-703 S/N LE15I247
SKID HEIGHT = 5 FEET

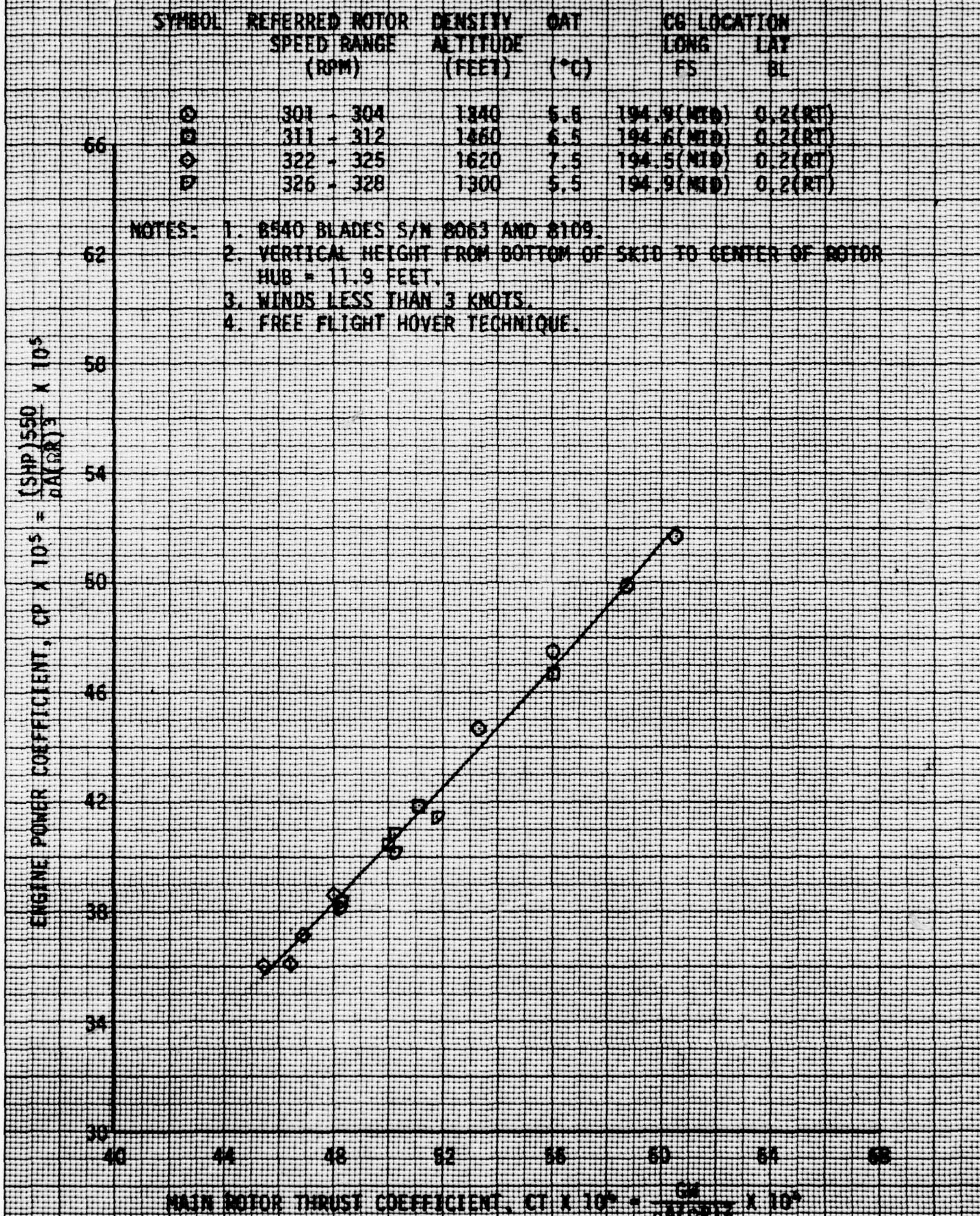


FIGURE 2
SUMMARY HOVER PERFORMANCE
OUT-OF-GROUND EFFECT
YAH-1R USA S/N 70-15936
INTERMEDIATE RATED POWER

NOTES:
1. SHP_{AVAIL} BASED ON FIGURE 72.
2. ROTOR SPEED = 324 RPM
3. SHP_{REQ} BASED ON FIGURES 5 THROUGH 8.
4. SKID HEIGHT = 100 FEET
5. K747 BLADES S/N 1005 AND 1009

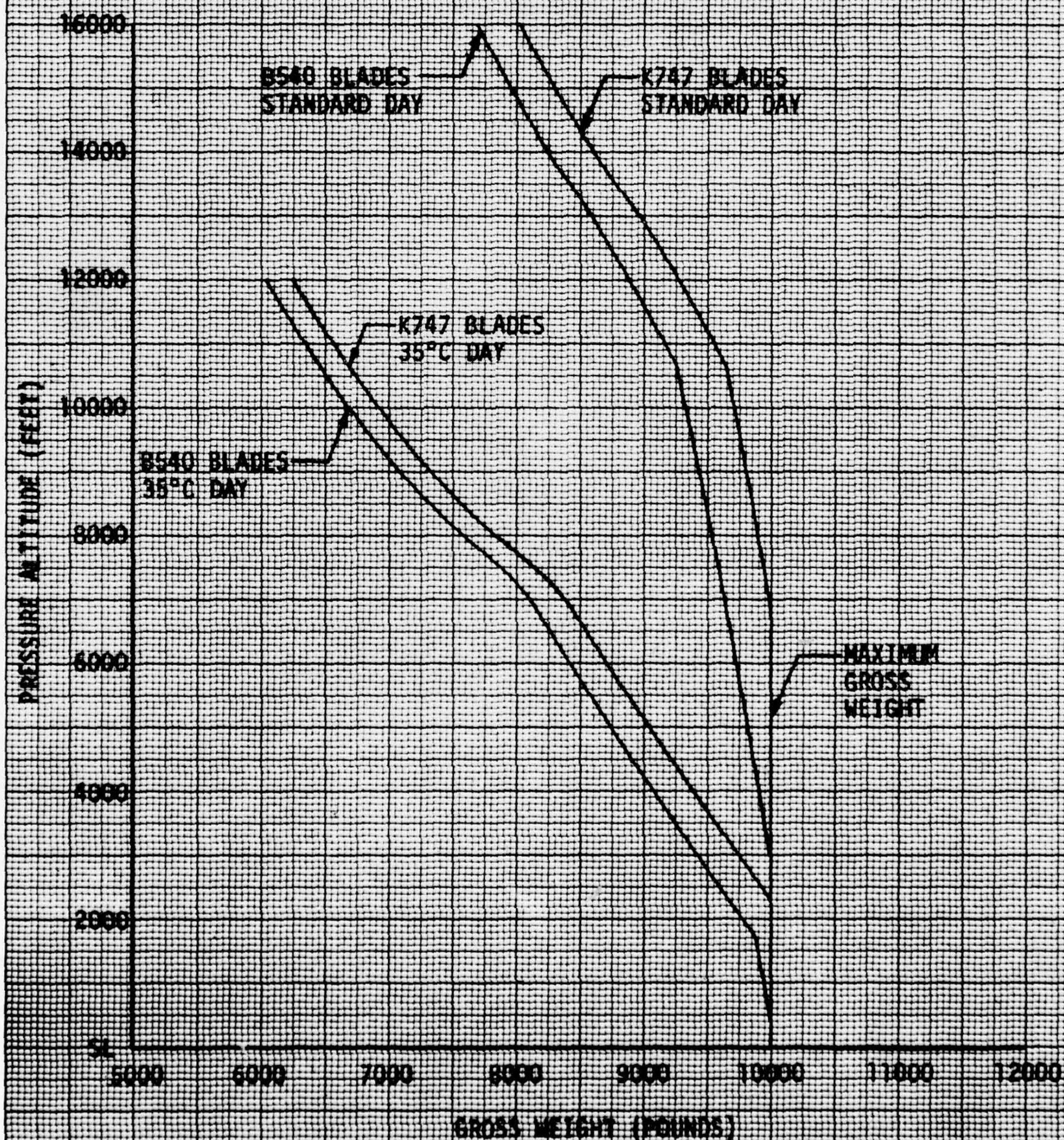
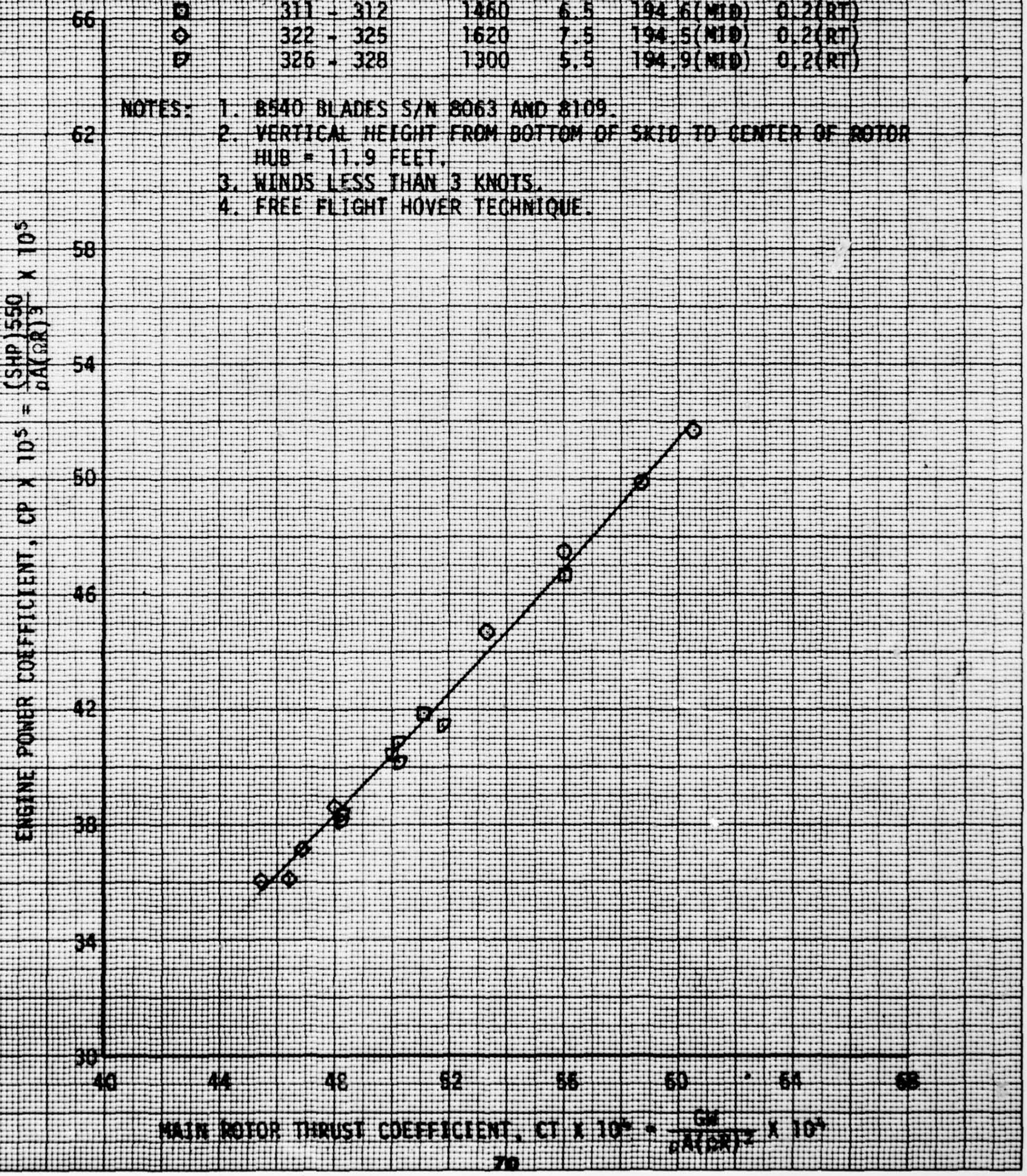


FIGURE 3
IN-GROUND EFFECT NONDIMENSIONAL HOVERING PERFORMANCE
YAH-1R USA S/N 70-15936
ENGINE T53-L-703 S/N LE18124Z
SKID HEIGHT = 5 FEET

SYMBOL	REFERRED ROTOR SPEED RANGE (RPM)	DENSITY ALTITUDE (FEET)	OAT (°C)	CG LOCATION LONG FS	CG LOCATION LAT BL
○	301 - 304	1840	5.6	194.9(MID)	0.2(RT)
□	311 - 312	1460	6.5	194.6(MID)	0.2(RT)
◇	322 - 325	1620	7.5	194.5(MID)	0.2(RT)
▽	326 - 328	1300	5.5	194.9(MID)	0.2(RT)

NOTES:
1. 8540 BLADES S/N 8063 AND 8109.
2. VERTICAL HEIGHT FROM BOTTOM OF SKID TO CENTER OF ROTOR HUB = 11.9 FEET.
3. WINDS LESS THAN 3 KNOTS.
4. FREE FLIGHT HOVER TECHNIQUE.



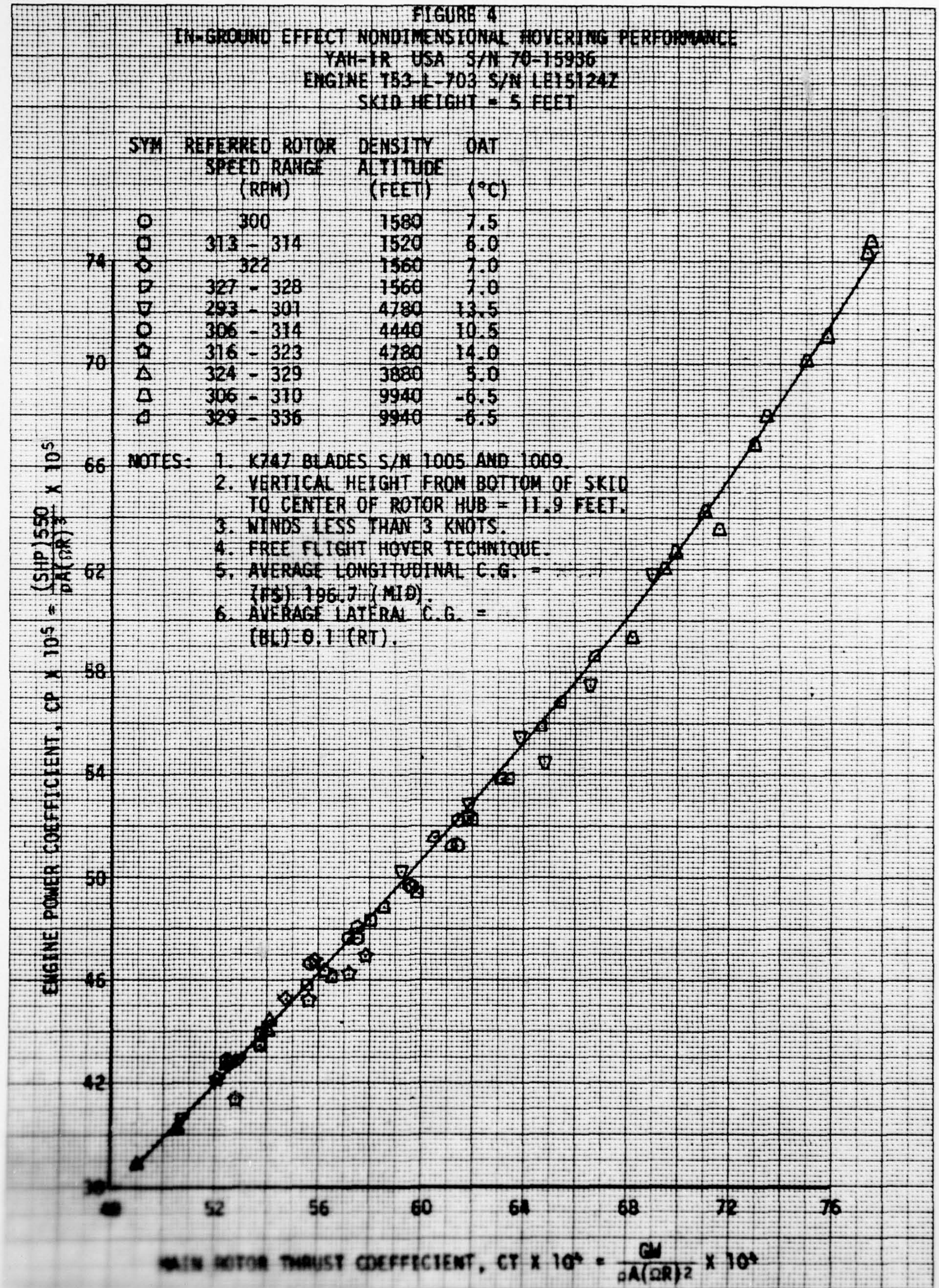


FIGURE 4
IN-GROUND EFFECT NONDIMENSIONAL HOVERING PERFORMANCE
YAH-1R USA S/N 70-15936
ENGINE T53-L-703 S/N LE15124Z
SKID HEIGHT = 5 FEET
SYM
REFERRED ROTOR SPEED RANGE (RPM)
DENSITY ALTITUDE (FEET)
OAT (°C)
300 1580 7.5
313 - 314 1520 6.0
322 1560 7.0
327 - 328 1560 7.0
293 - 301 4780 13.5
306 - 314 4440 10.5
316 - 323 4780 14.0
324 - 329 3880 5.0
306 - 310 9940 -6.5
329 - 336 9940 -6.5
NOTES: 1. K747 BLADES S/N 1005 AND 1009.
2. VERTICAL HEIGHT FROM BOTTOM OF SKID TO CENTER OF ROTOR HUB = 11.9 FEET.
3. WINDS LESS THAN 3 KNOTS.
4. FREE FLIGHT HOVER TECHNIQUE.
5. AVERAGE LONGITUDINAL C.G. = (FS) 196.7 (MID).
6. AVERAGE LATERAL C.G. = (BL) 0.1 (RT).
ENGINE POWER COEFFICIENT, CP X 10^5 = (SHP)550 / ρA(ΩR)^3 X 10^5
MAIN ROTOR THRUST COEFFICIENT, CT X 10^4 = GW / ρA(ΩR)^2 X 10^4
38
42
46
50
54
58
62
66
70
74
48
52
56
60
64
68
72
76

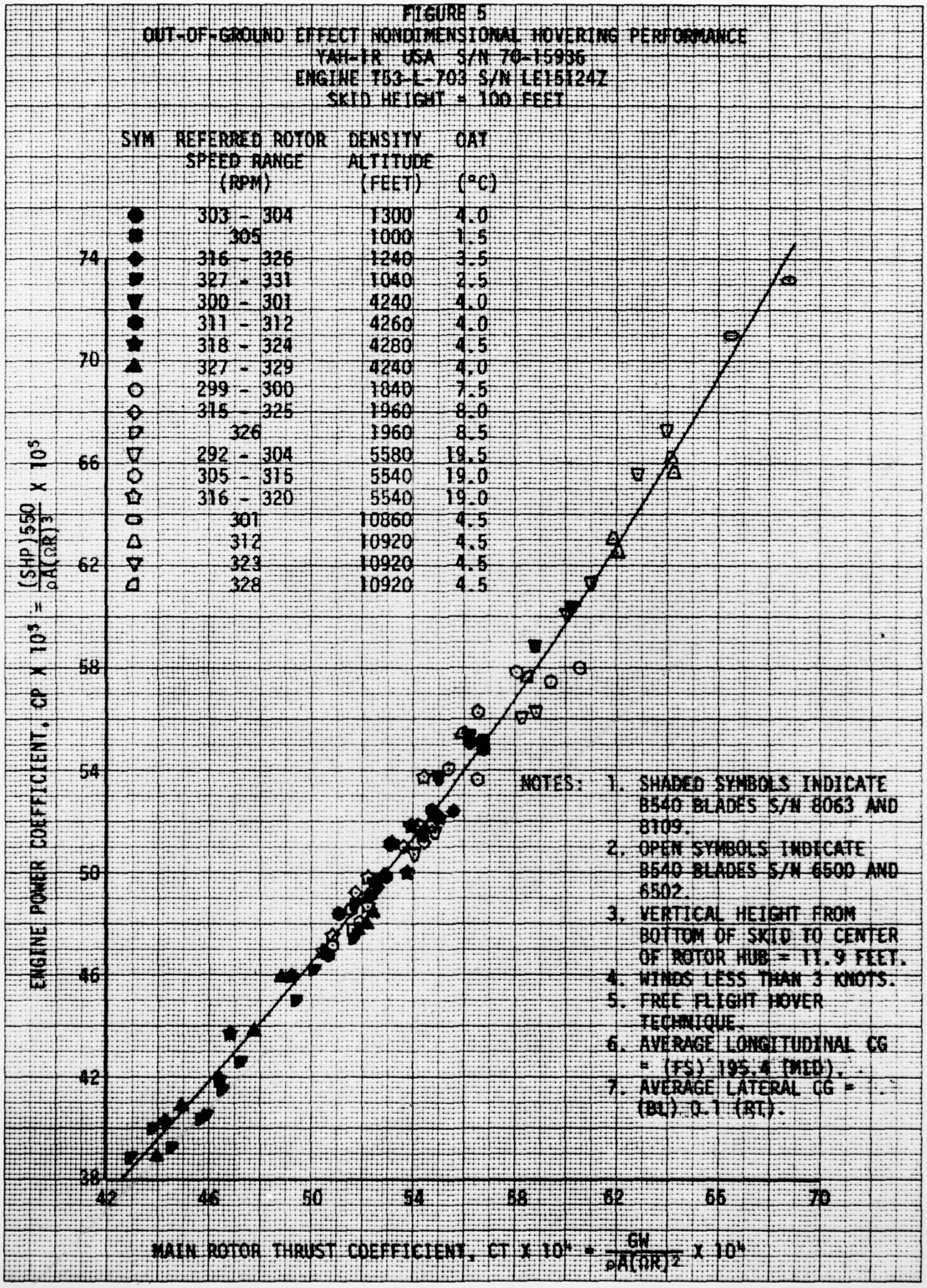


FIGURE 5
OUT-OF-GROUND EFFECT NONDIMENSIONAL HOVERING PERFORMANCE
YAH-1R USA S/N 70-15936
ENGINE T53-L-703 S/N LE15124Z
SKID HEIGHT = 100 FEET
SYM
REFERRED ROTOR SPEED RANGE (RPM)
DENSITY ALTITUDE (FEET)
OAT (°C)
303 - 304 1300 4.0
305 1000 1.5
316 - 326 1240 3.5
327 - 331 1040 2.5
300 - 301 4240 4.0
311 - 312 4260 4.0
318 - 324 4280 4.5
327 - 329 4240 4.0
299 - 300 1840 7.5
315 - 325 1960 8.0
326 1960 8.5
292 - 304 5580 19.5
305 - 315 5540 19.0
316 - 320 5540 19.0
301 10860 4.5
312 10920 4.5
323 10920 4.5
328 10920 4.5
NOTES:
1. SHADED SYMBOLS INDICATE B540 BLADES S/N 8063 AND 8109.
2. OPEN SYMBOLS INDICATE B540 BLADES S/N 6500 AND 6502.
3. VERTICAL HEIGHT FROM BOTTOM OF SKID TO CENTER OF ROTOR HUB = 11.9 FEET.
4. WINDS LESS THAN 3 KNOTS.
5. FREE FLIGHT HOVER TECHNIQUE.
6. AVERAGE LONGITUDINAL CG = (FS) 195.4 (MID).
7. AVERAGE LATERAL CG = (BL) 0.1 (RT).
ENGINE POWER COEFFICIENT, CP X 10^5 = $\frac{(SHP)550}{\rho A(\Omega R)^3}$ X 10^5
38
42
46
50
54
58
62
66
70
74
MAIN ROTOR THRUST COEFFICIENT, CT X 10^4 = $\frac{GW}{\rho A(\Omega R)^2}$ X 10^4
42
46
50
54
58
62
66
70

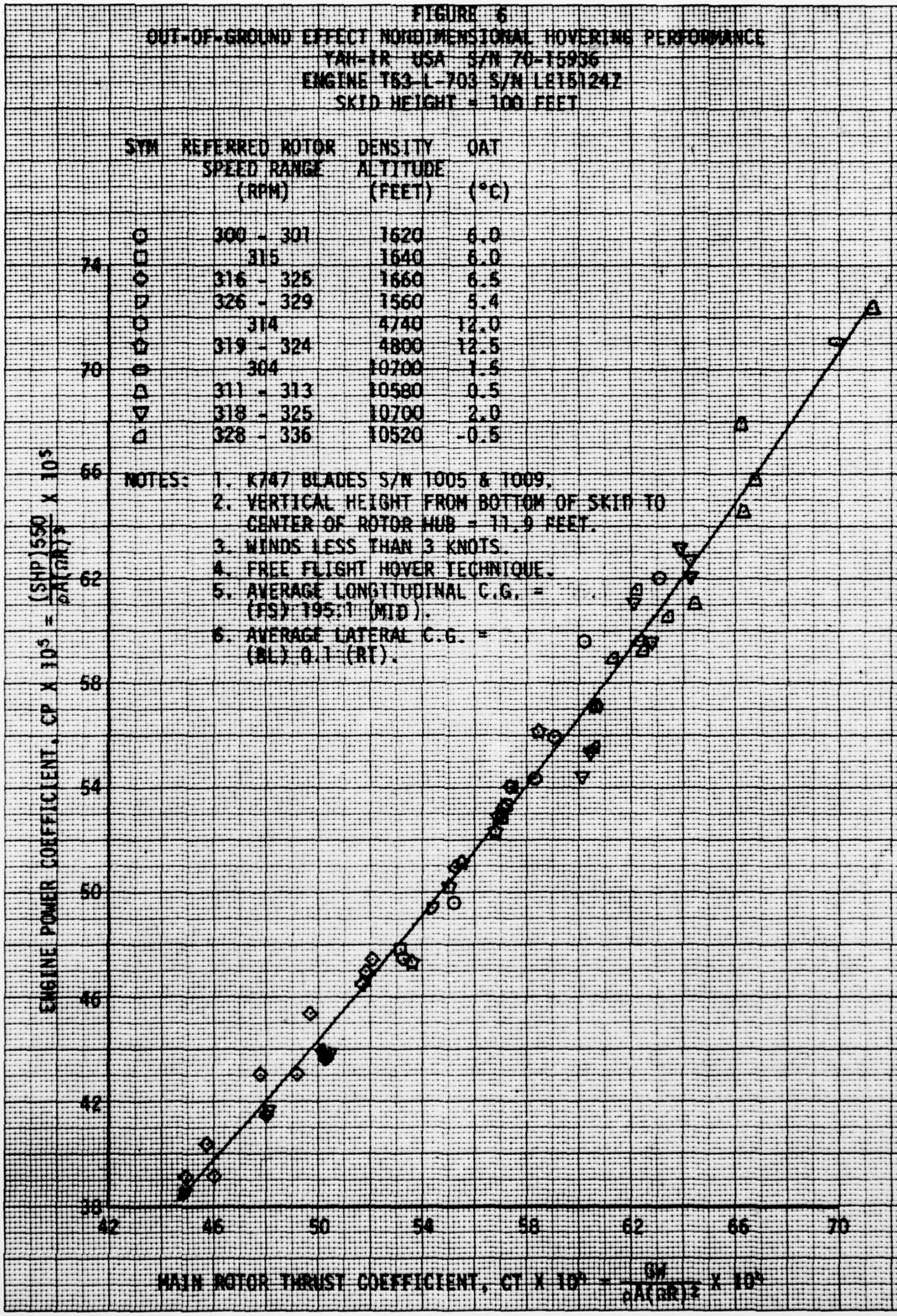
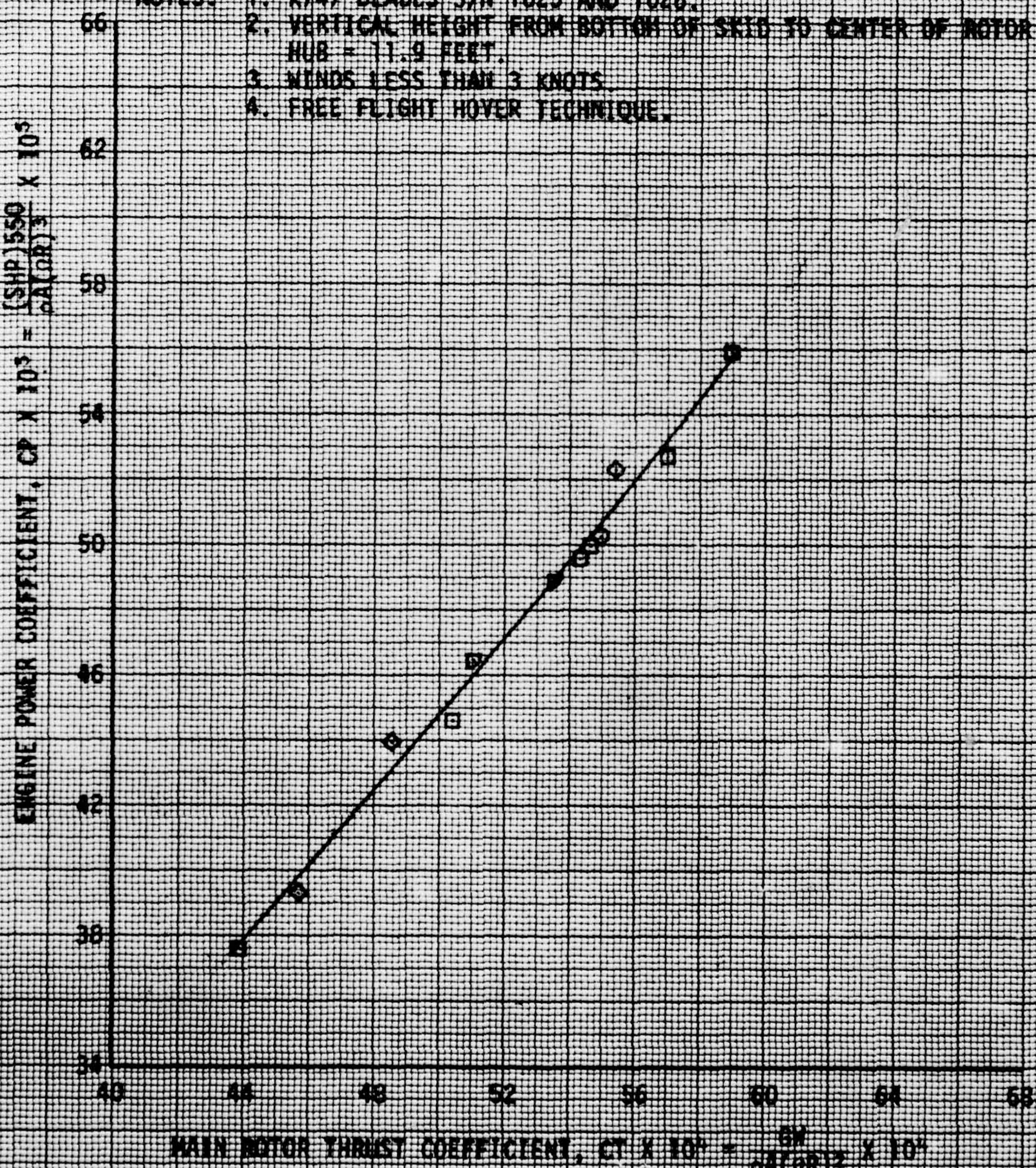


FIGURE 6
OUT-OF-GROUND EFFECT NONDIMENSIONAL HOVERING PERFORMANCE
YAH-1R USA S/N 70-15936
ENGINE T53-L-703 S/N LE151247
SKID HEIGHT = 100 FEET
SYM
REFERRED ROTOR SPEED RANGE (RPM)
DENSITY ALTITUDE (FEET)
OAT (°C)
300 - 301 1620 6.0
315 1640 6.0
316 - 325 1660 6.5
326 - 329 1560 5.4
314 4740 12.0
319 - 324 4800 12.5
304 10700 1.5
311 - 313 10580 0.5
318 - 325 10700 2.0
328 - 336 10520 -0.5
NOTES: 1. K747 BLADES S/N 1005 & 1009.
2. VERTICAL HEIGHT FROM BOTTOM OF SKID TO CENTER OF ROTOR HUB = 11.9 FEET.
3. WINDS LESS THAN 3 KNOTS.
4. FREE FLIGHT HOVER TECHNIQUE.
5. AVERAGE LONGITUDINAL C.G. = (FS) 195.1 (MID).
6. AVERAGE LATERAL C.G. = (BL) 0.1 (RT).
ENGINE POWER COEFFICIENT, CP X 10⁵ = (SHP)550 / ρA(ΩR)³ X 10⁵
38
42
46
50
54
58
62
66
70
74
42
46
50
54
58
62
66
70
MAIN ROTOR THRUST COEFFICIENT, CT X 10⁴ = GW / ρA(ΩR)² X 10⁴

FIGURE 7
OUT-OF-GROUND EFFECT NONDIMENSIONAL HOVERING PERFORMANCE
YAH-1R USA S/N 70-15936
ENGINE T53-L-703 S/N LE15124Z
SKID HEIGHT = 100 FEET

SYMBOL	REFERRED ROTOR SPEED RANGE (RPM)	DENSITY ALTITUDE (FEET)	OAT (°C)	CG LOCATION LONG FS	CG LOCATION LAT BL
○	299	1660	5.0	194.9(MID)	0.2(RT)
□	311 - 312	1620	4.5	195.4(MID)	0.2(RT)
◇	321 - 322	1700	5.0	195.3(MID)	0.2(RT)
◩	327 - 328	1620	4.5	195.4(MID)	0.2(RT)

NOTES:
1. K747 BLADES S/N 1025 AND 1026.
2. VERTICAL HEIGHT FROM BOTTOM OF SKID TO CENTER OF ROTOR HUB = 11.9 FEET.
3. WINDS LESS THAN 3 KNOTS.
4. FREE FLIGHT HOVER TECHNIQUE.



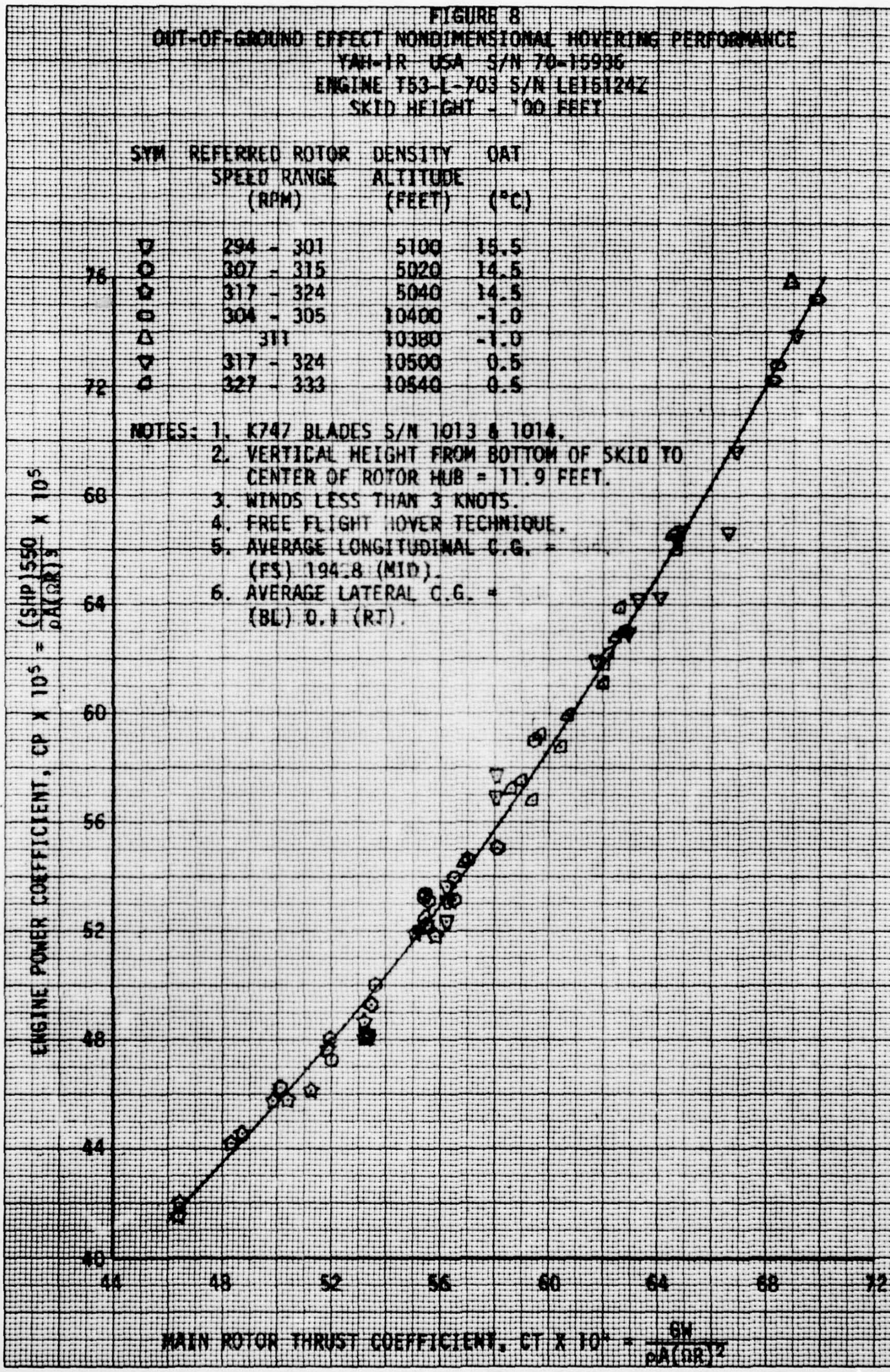
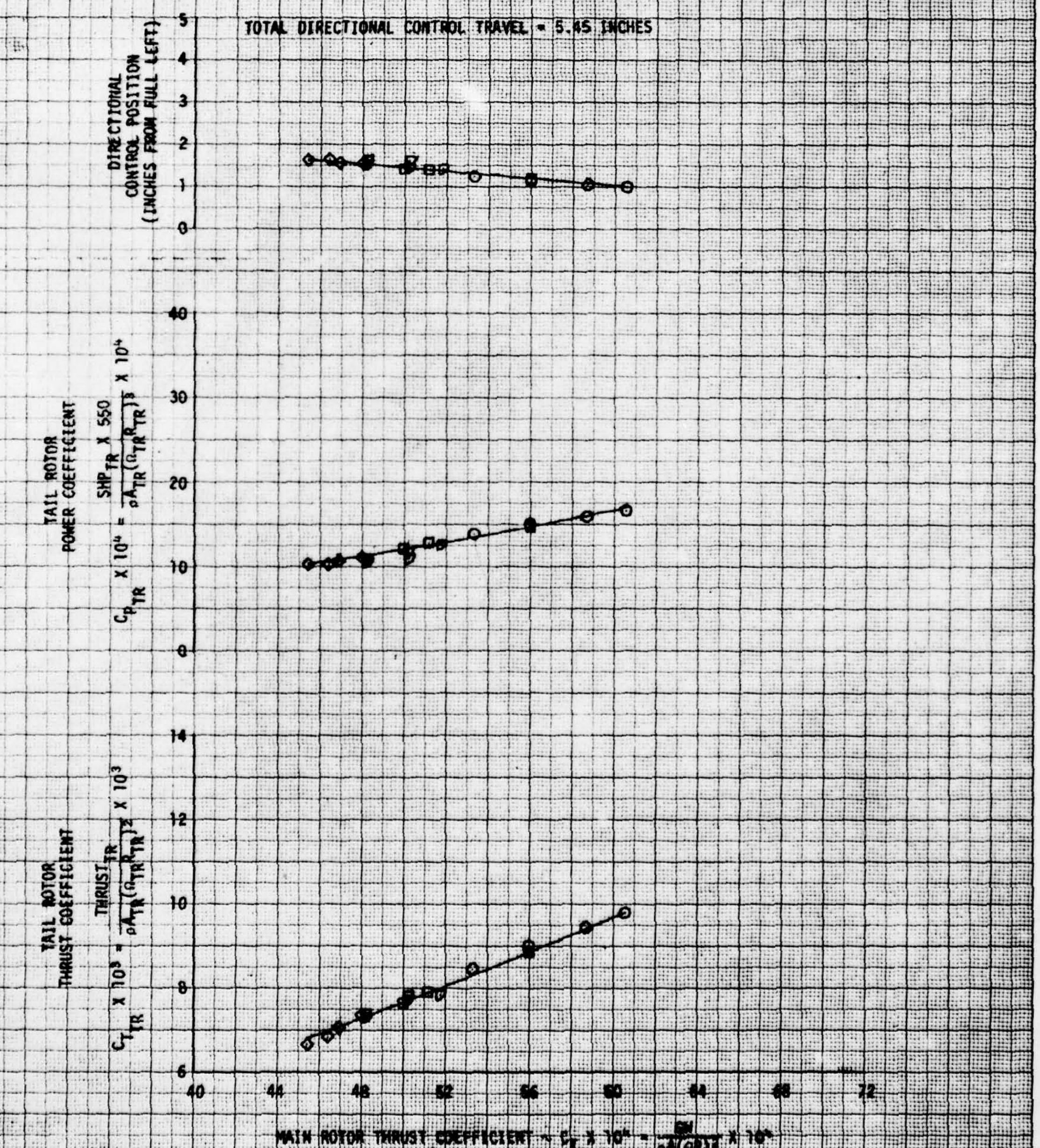


FIGURE 8
OUT-OF-GROUND EFFECT NONDIMENSIONAL HOVERING PERFORMANCE
YAH-1R USA S/N 70-15936
ENGINE T53-L-703 S/N LE15124Z
SKID HEIGHT - 100 FEET

FIGURE 9
NON-DIMENSIONAL TAIL ROTOR PERFORMANCE
YAH-1R USA S/N 70-15936
ENGINE T53-L-703 S/N LE151247
SKID HEIGHT = 5 FEET

SYM	REFERRED ROTOR SPEED RANGE (RPM)	DENSITY ALTITUDE (FEET)	OAT (°C)
○	301 - 304	1340	5.5
□	311 - 312	1460	6.5
◇	322 - 325	1620	7.5
▽	326 - 328	1300	5.5

NOTE : B540 BLADES S/N 8063 AND 8109.



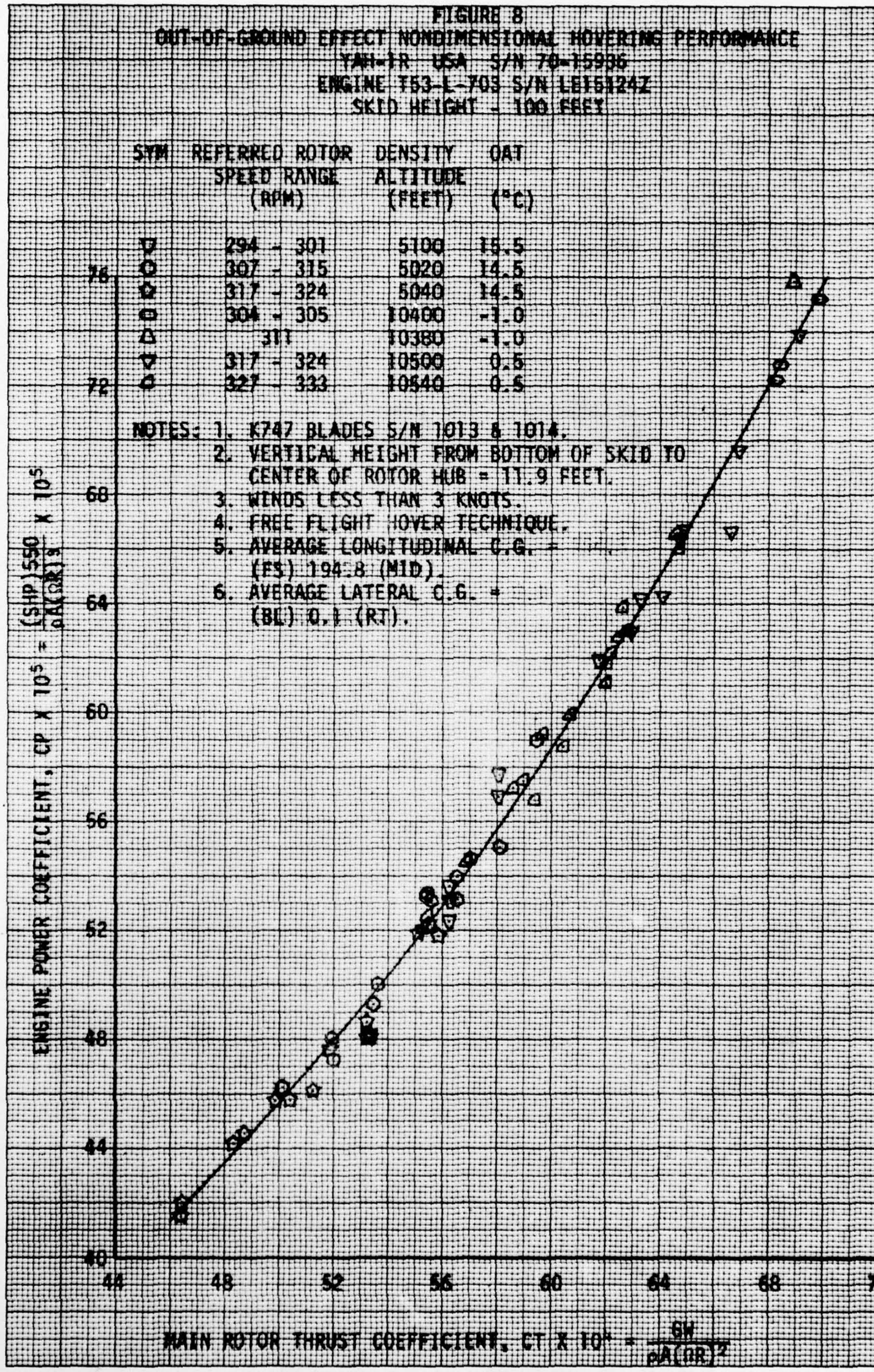


FIGURE 8
OUT-OF-GROUND EFFECT NONDIMENSIONAL HOVERING PERFORMANCE
YAH-1R USA S/N 70-15936
ENGINE T53-L-703 S/N LE151242
SKID HEIGHT - 100 FEET

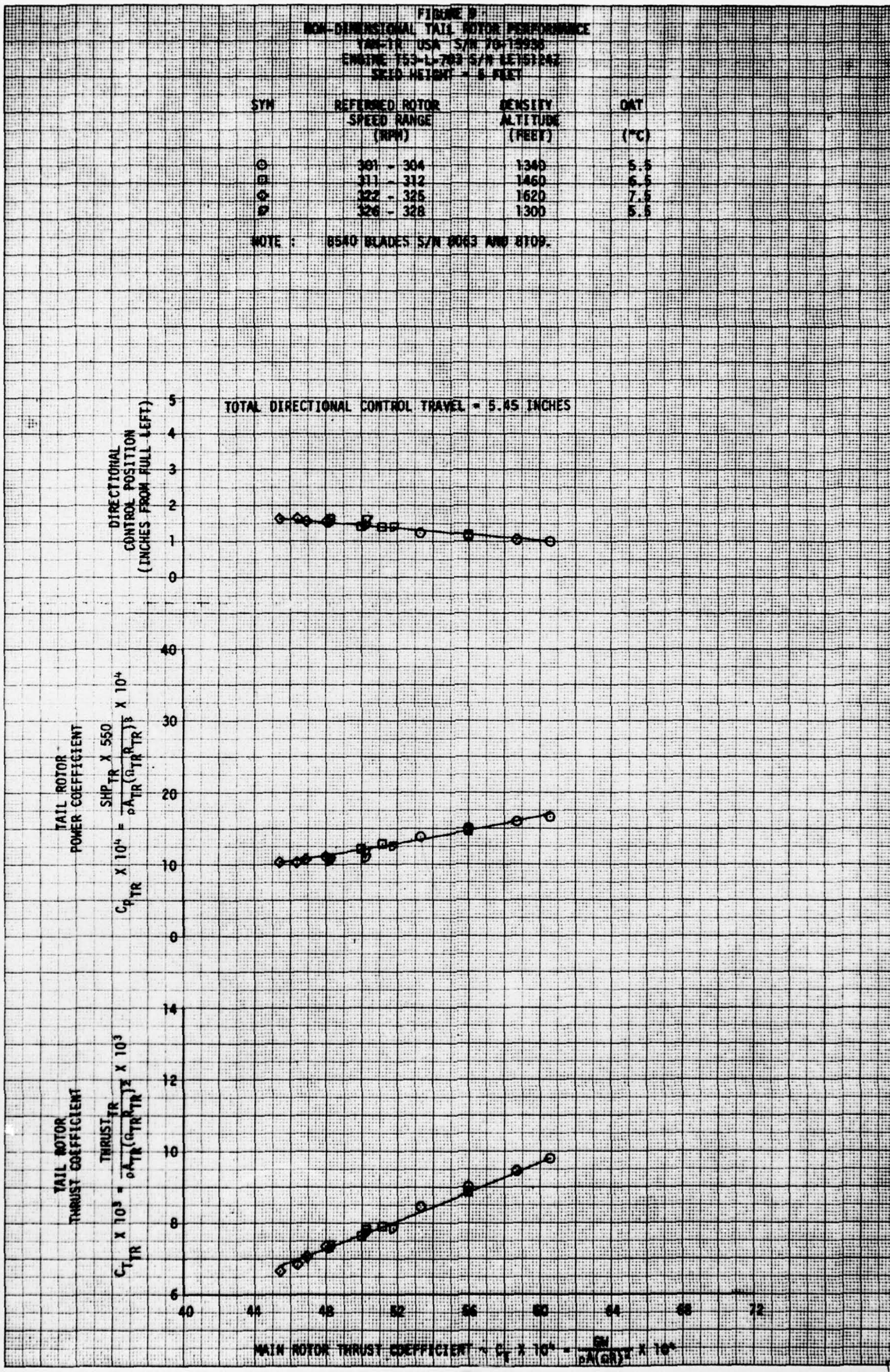


FIGURE 9
NON-DIMENSIONAL TAIL ROTOR PERFORMANCE
YAH-1R USA S/N 70-15936
ENGINE T53-L-703 S/N LE151242
SKID HEIGHT = 6 FEET
SYM
REFERRED ROTOR SPEED RANGE (RPM)
DENSITY ALTITUDE (FEET)
OAT (°C)
301 - 304
1340
5.5
311 - 312
1460
6.5
322 - 325
1620
7.5
326 - 328
1300
5.5
NOTE : B540 BLADES S/N 8063 AND 8109.
TOTAL DIRECTIONAL CONTROL TRAVEL = 5.45 INCHES
DIRECTIONAL CONTROL POSITION (INCHES FROM FULL LEFT)
TAIL ROTOR POWER COEFFICIENT
$C_{P_{TR}} \times 10^4 = \frac{SHP_{TR} \times 550}{\rho A_{TR}(\Omega_{TR} R_{TR})^3} \times 10^4$
TAIL ROTOR THRUST COEFFICIENT
$C_{T_{TR}} \times 10^3 = \frac{THRUST_{TR}}{\rho A_{TR}(\Omega_{TR} R_{TR})^2} \times 10^3$
MAIN ROTOR THRUST COEFFICIENT ~ $C_T \times 10^4 = \frac{GW}{\rho A(\Omega R)^2} \times 10^4$
0
1
2
3
4
5
10
20
30
40
6
8
10
12
14
40
44
48
52
56
60
64
68
72

FIGURE 10
NON-DIMENSIONAL TAIL ROTOR PERFORMANCE
YAH-1R USA S/N 70-15936
ENGINE T53-L-703 S/N LE151242
SKID HEIGHT = 5 FEET

SYM	REFERRED ROTOR SPEED RANGE (RPM)	DENSITY ALTITUDE (FEET)	OAT (°C)
○	300	1580	7.5
□	313 - 314	1520	6.0
◇	322	1560	7.0
◸	327 - 328	1560	7.0
▽	293 - 201	4780	13.5
○	306 - 314	4440	10.5
⌂	316 - 323	4780	14.0
△	324 - 329	3880	5.0
△	306 - 310	9940	-6.5
◁	329 - 336	9940	-6.5

NOTE : K747 BLADES S/N 1005 AND 1009.

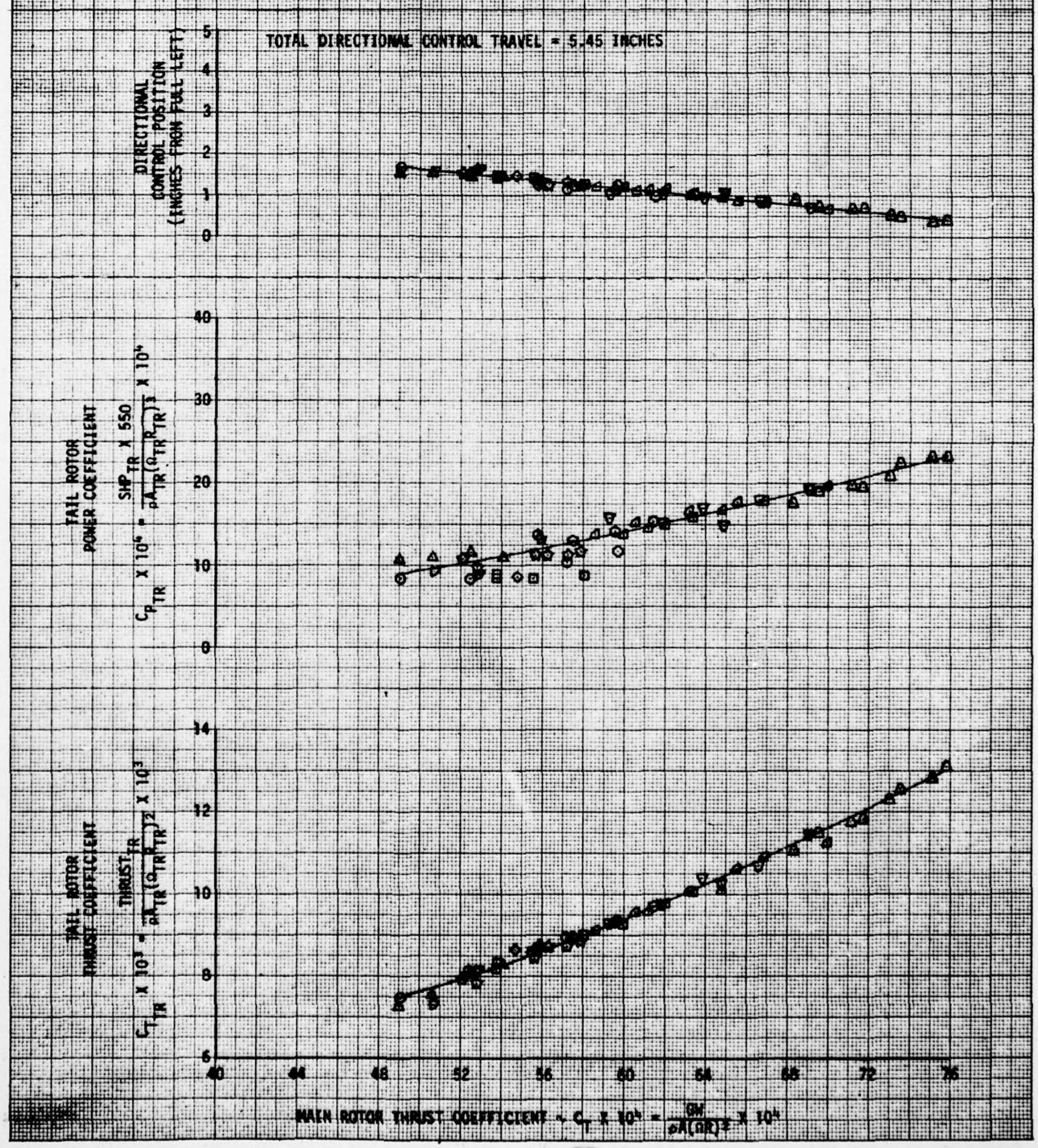


FIGURE 11
NON-DIMENSIONAL TAIL ROTOR PERFORMANCE
TAH-1E USA S/N 70-15936
ENGINE T53-L-703 S/N LE151242
SKID HEIGHT = 100 FEET

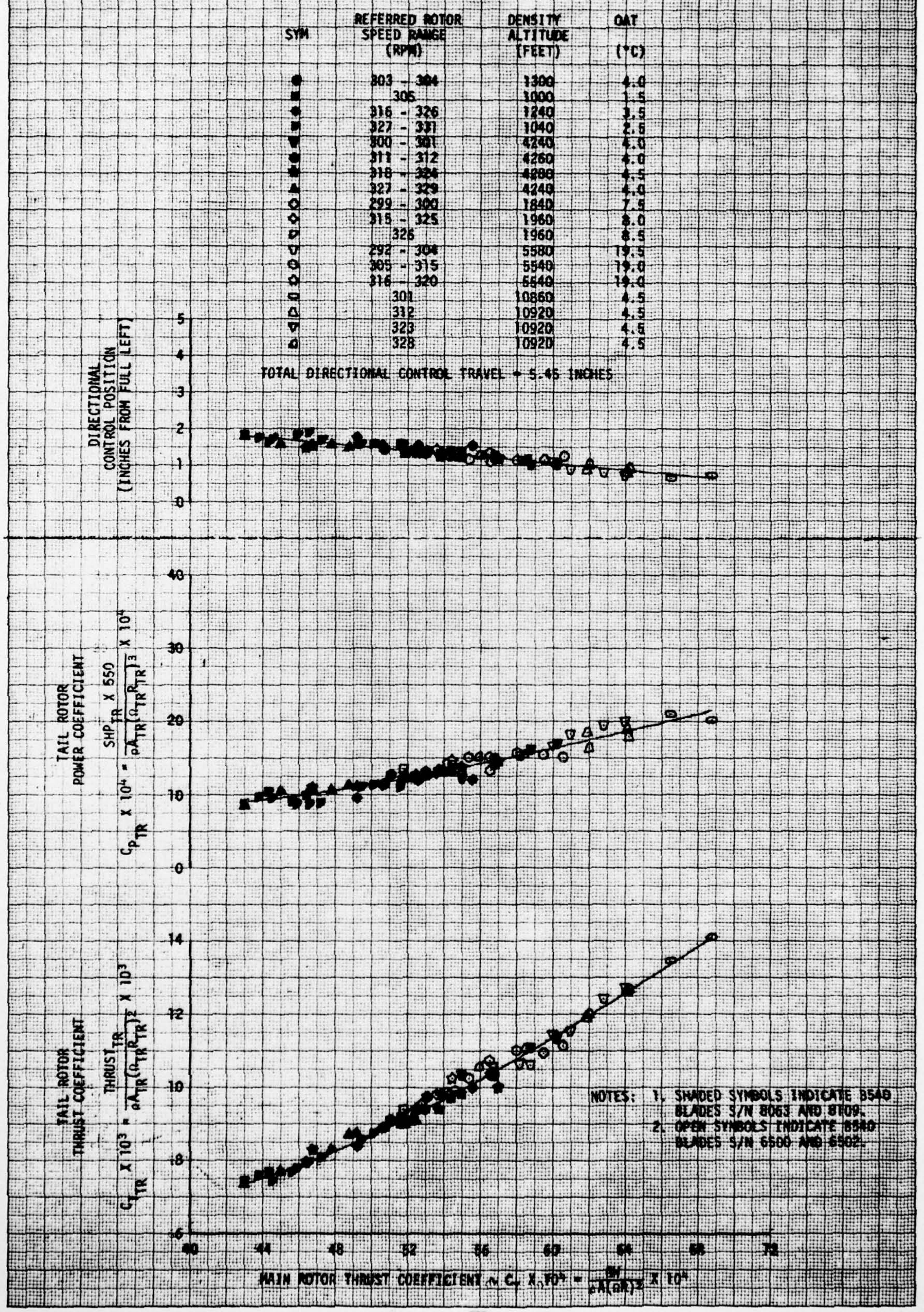


FIGURE 12
NON-DIMENSIONAL TAIL ROTOR PERFORMANCE
YAH-1R USA S/N 70-15936
ENGINE T53-L-703 S/N LE15124Z
SKID HEIGHT = 100 FEET

SYM	REFERRED ROTOR SPEED RANGE (RPM)	DENSITY ALTITUDE (FEET)	OAT (°C)
○	300 - 301	1620	6.0
□	315	1640	6.0
◇	316 - 325	1660	6.5
▽	326 - 329	1560	5.4
○	314	4740	12.0
☆	319 - 324	4800	12.5
●	304	10700	1.5
△	311 - 313	10680	0.5
▽	318 - 325	10700	2.0
△	328 - 336	10520	-0.5

NOTE : K747 BLADES S/N 1005 AND 1009.

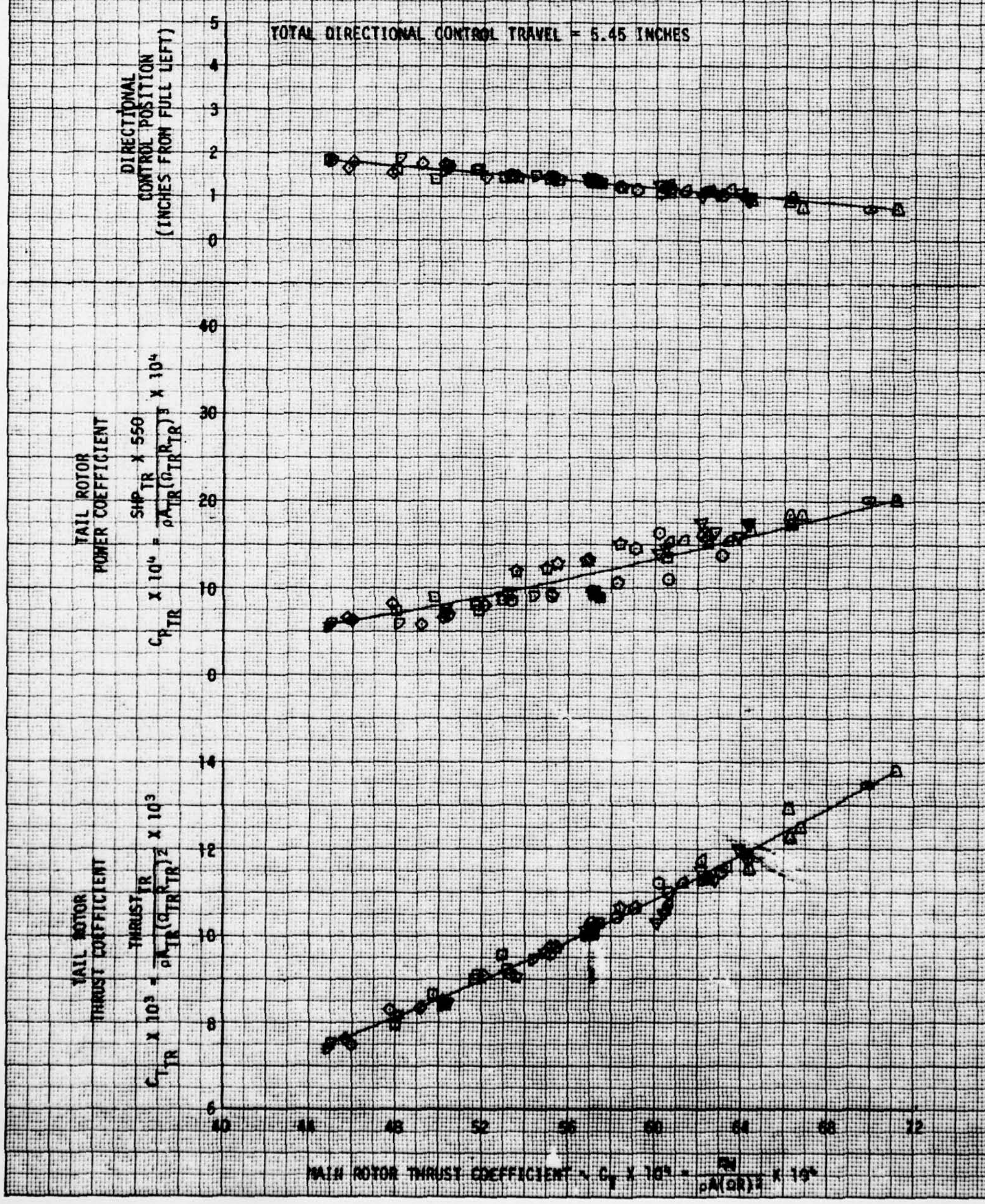


FIGURE 13
CLIMB PERFORMANCE SUMMARY
YAH-1R USA S/N 70-15936

NOTES:
1. 8540 BLADES S/N 8063 AND 8109.
2. SHP_{AVAIL} BASED ON FIG. 72.
3. MAXIMUM RATE OF CLIMB AIRSPEED AND SHP_{REQ} BASED ON FIGS. 20 THROUGH 22.
4. RATE OF CLIMB DERIVED FROM FIG. 15.
5. 8-TON CONFIGURATION.
6. ROTOR SPEED = 324 RPM.
7. ZERO SIDESLIP.

——— DENOTES STANDARD DAY.
— — DENOTES 35°C DAY.

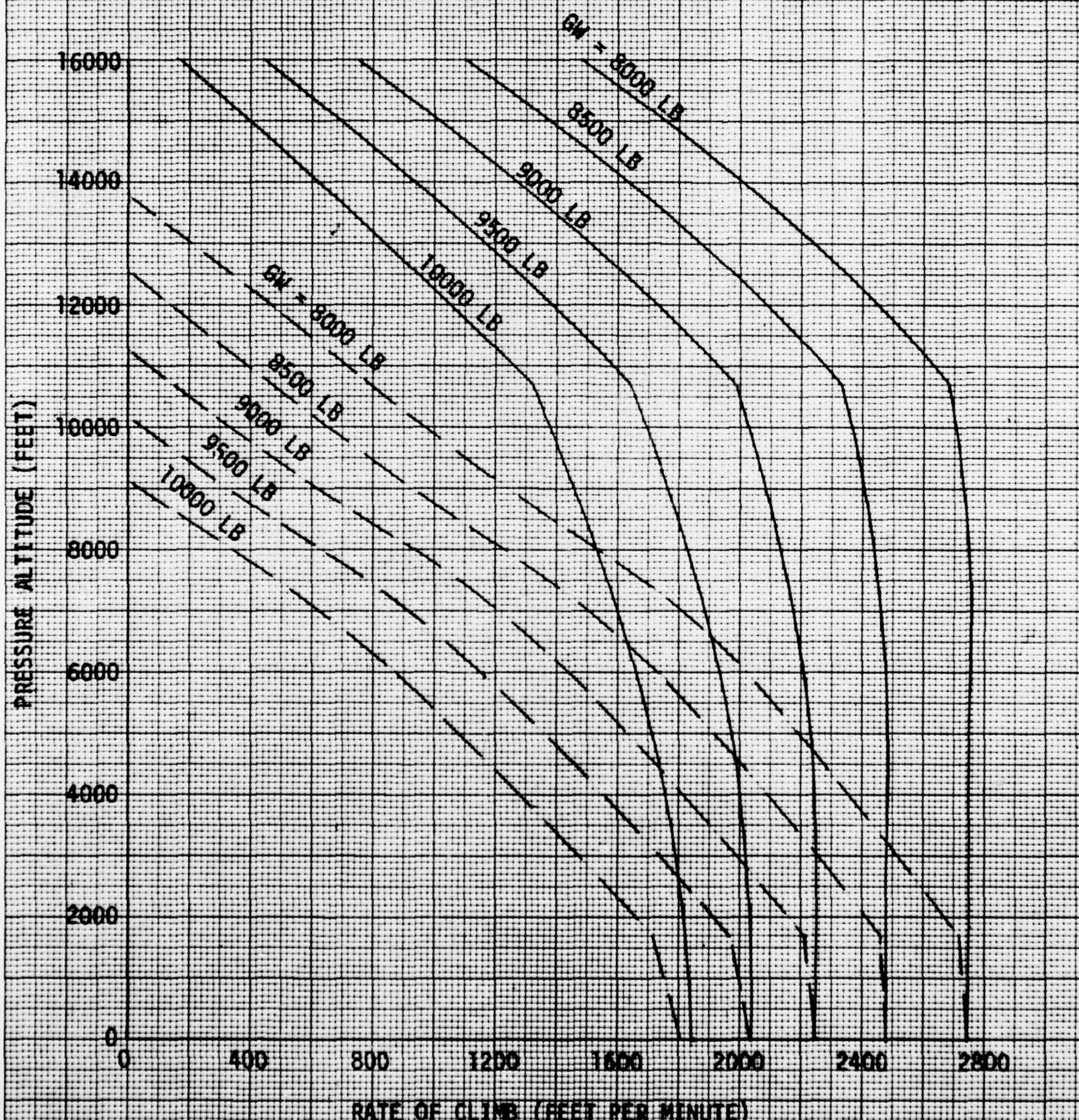


FIGURE 14
CLIMB PERFORMANCE SUMMARY
YAH-1R USA S/N 70-15936

NOTES: 1. K747 BLADES S/N 1006 AND 1009.
2. SHP_{AVAIL} BASED ON FIG. 72.
3. MAXIMUM RATE OF CLIMB AIRSPEED AND SHP_{REQ} BASED ON FIGS. 23 AND 24.
4. RATE OF CLIMB DERIVED FROM FIG. 16.
5. 8-TOW CONFIGURATION.
6. ROTOR SPEED = 324 RPM.
7. ZERO SIDESLIP.
——— DENOTES STANDARD DAY.
— — DENOTES 35°C DAY.

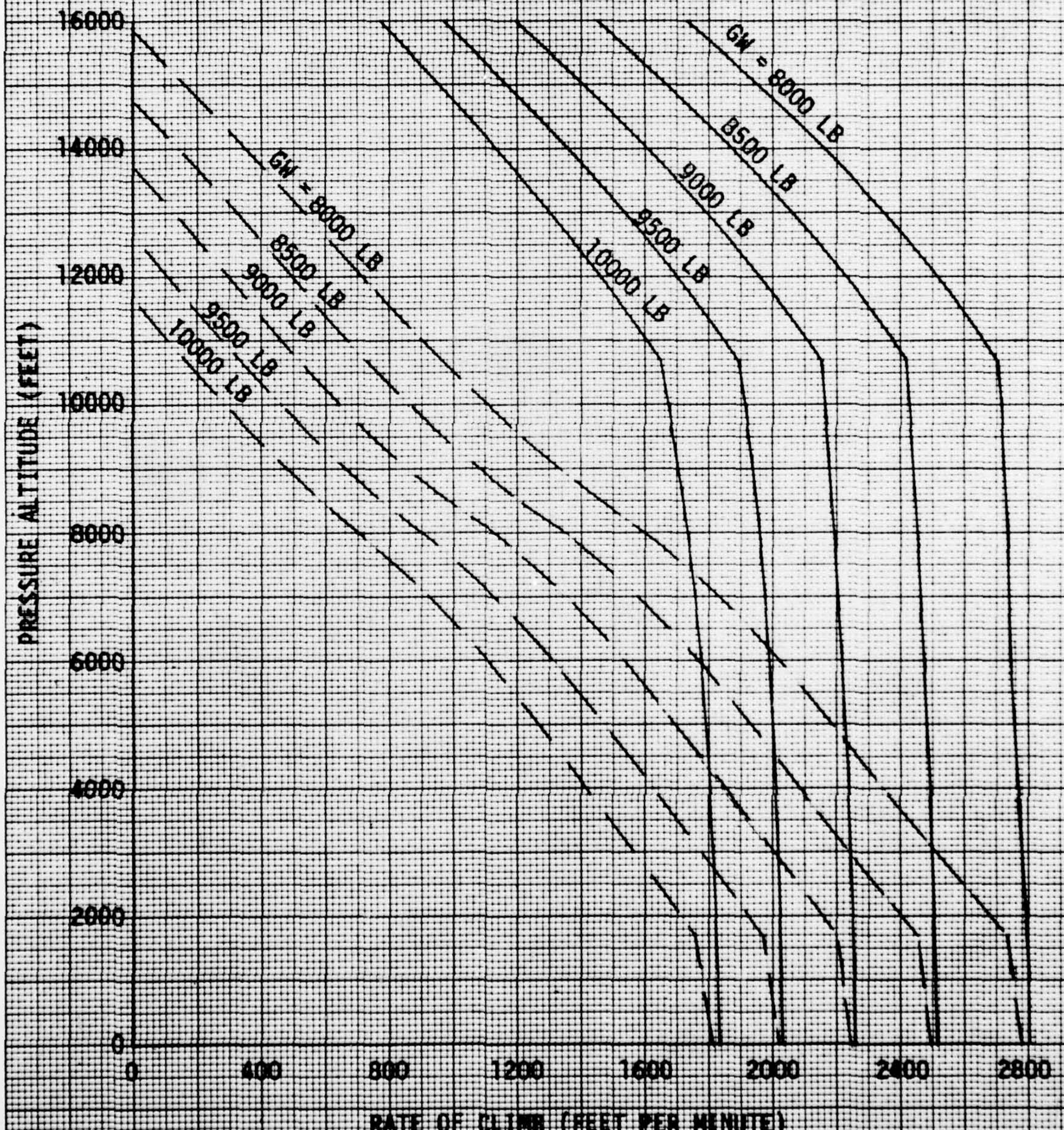


FIGURE 15
GENERALIZED CLIMB AND DESCENT PERFORMANCE
YAH-1R USA S/N 70-15936

SYMBOL	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	AVG C_T	FORWARD VELOCITY RATIO
○	8920	194.5(MID)	0.2(RT)	12.5	324	0.00523	3.0
□	9060	194.3(MID)	0.2(RT)	3.5	324	0.00538	3.1
△	9240	194.7(MID)	0.2(RT)	13.0	324	0.00527	3.1
◇	8960	194.4(MID)	0.2(RT)	13.5	324	0.00510	5.1
△	8820	194.3(MID)	0.2(RT)	14.0	324	0.00511	2.1
□	9380	194.8(MID)	0.2(RT)	12.0	324	0.00558	4.0

NOTES: 1. B540 BLADES S/N 8063 AND 8109.
2. 8-TOW CONFIGURATION.
3. DATA DERIVED FROM FIGS. 20 THROUGH 22.

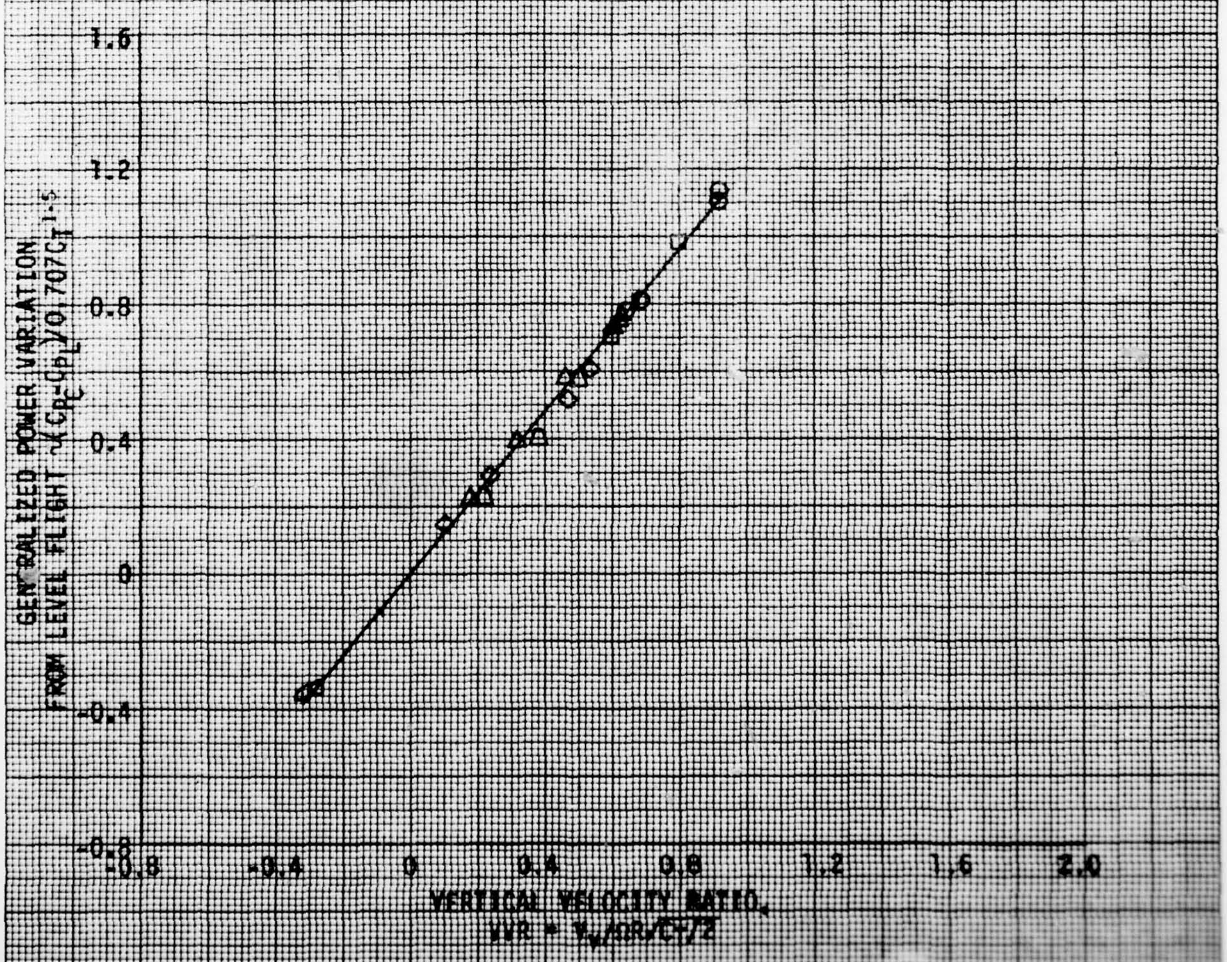


FIGURE 16
GENERALIZED CLIMB AND DESCENT PERFORMANCE
YAH-1R USA S/N 70-15936

SYMBOL	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	AVG C_T	FORWARD VELOCITY RADIO
○	9480	196.3(MID)	0.1(RT)	4.5	324	0.00549	3.3
□	9200	196.2(MID)	0.1(RT)	3.5	324	0.00546	2.5
◇	8940	195.9(MID)	0.1(RT)	2.5	324	0.00540	5.2
△	9260	196.1(MID)	0.1(RT)	2.5	324	0.00550	4.3
□	9140	196.2(MID)	0.1(RT)	2.5	324	0.00547	5.2
○	9080	195.8(MID)	0.1(RT)	2.0	324	0.00547	2.8
△	8920	195.9(MID)	0.1(RT)	2.0	324	0.00550	2.6
○	8820	196.1(MID)	0.1(RT)	2.5	324	0.00552	2.5

NOTES:
1. K747 BLADES S/N 1005 and 1009.
2. 8-TOW CONFIGURATION.
3. DATA DERIVED FROM FIGS. 23 AND 24.

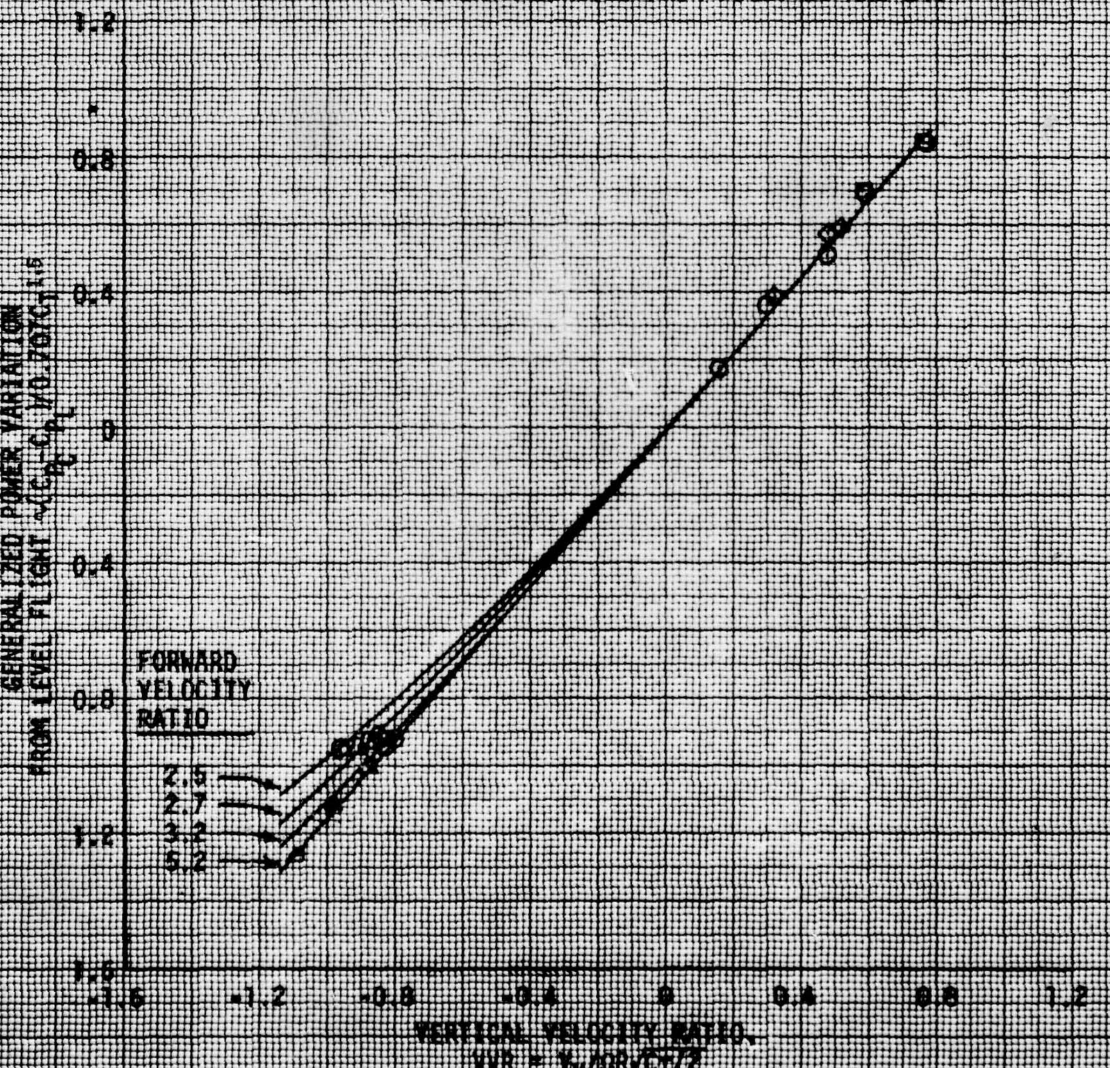


FIGURE 17
FORWARD FLIGHT CLIMB PERFORMANCE
YAH-1R USA S/N 70-15936
ENGINE T53-L-703 S/N LE 15124Z
B640 BLADES S/N B063 AND B109

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	CONFIGURATION
9500	194.4(MID)	0.1(RT)	4800	14.0	321	8-TOW

NOTES: 1. CURVE DERIVED FROM FIGS. 15 AND 20 THROUGH 22.
2. ENGINE SHP = 1100

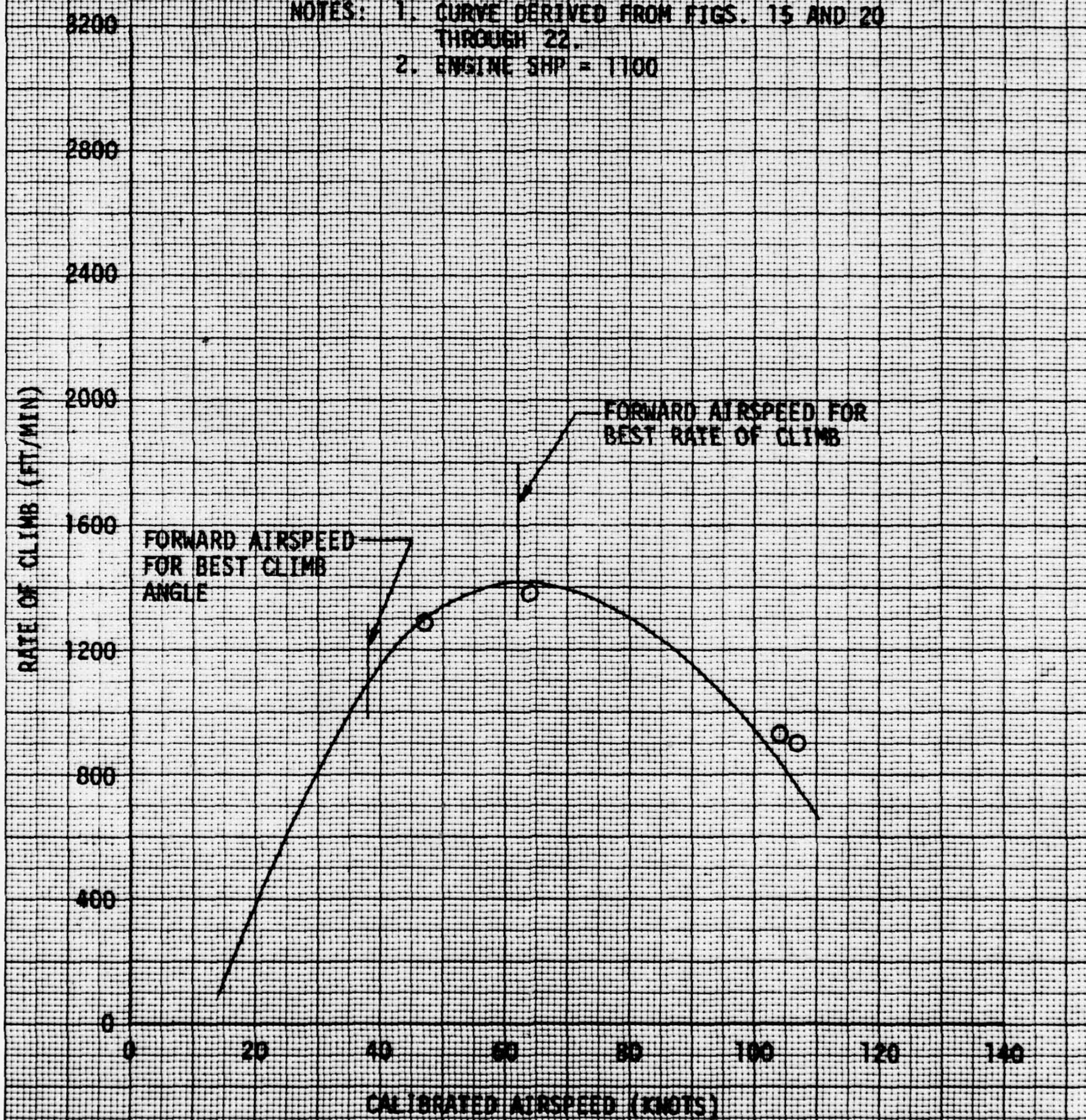
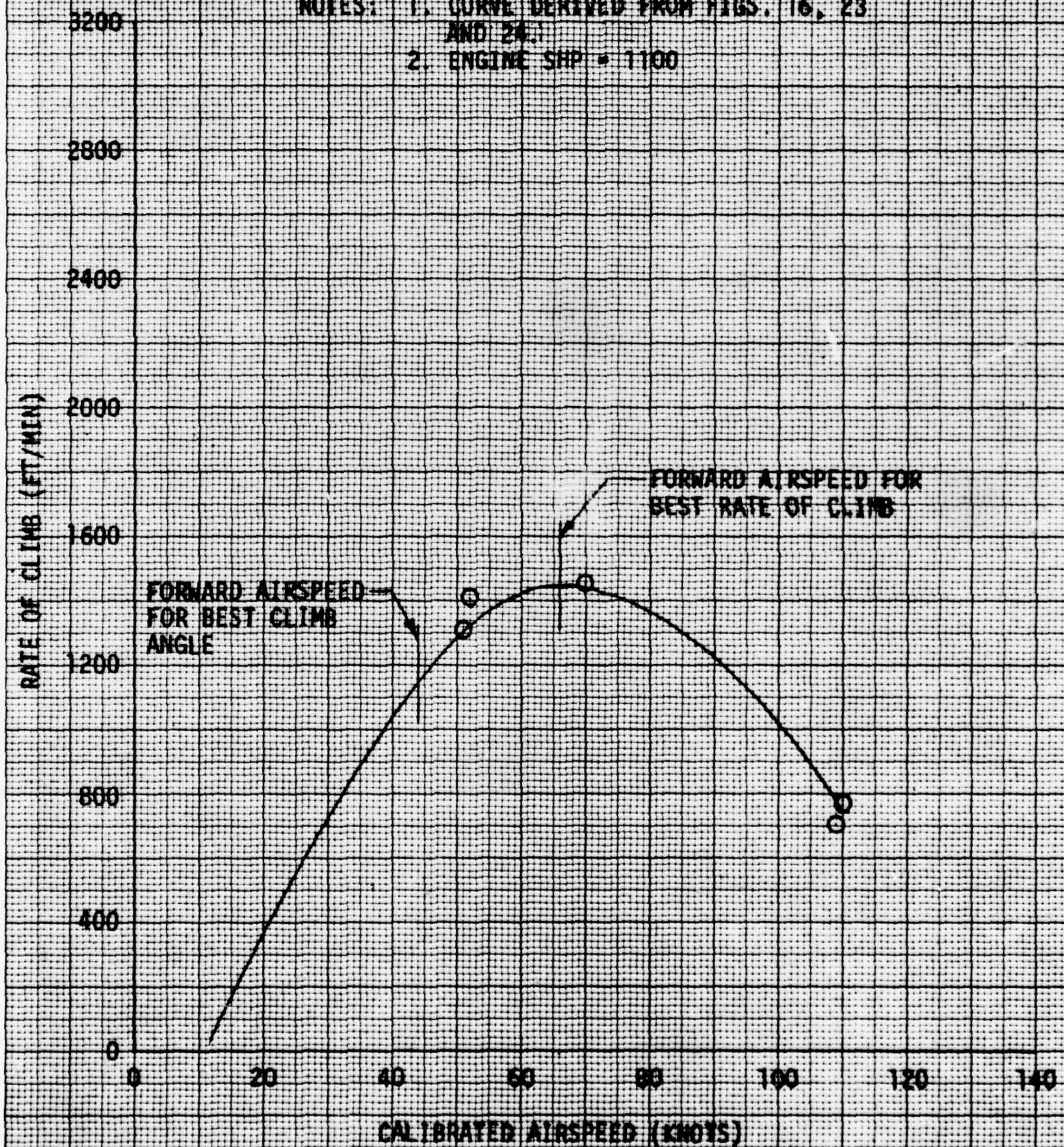
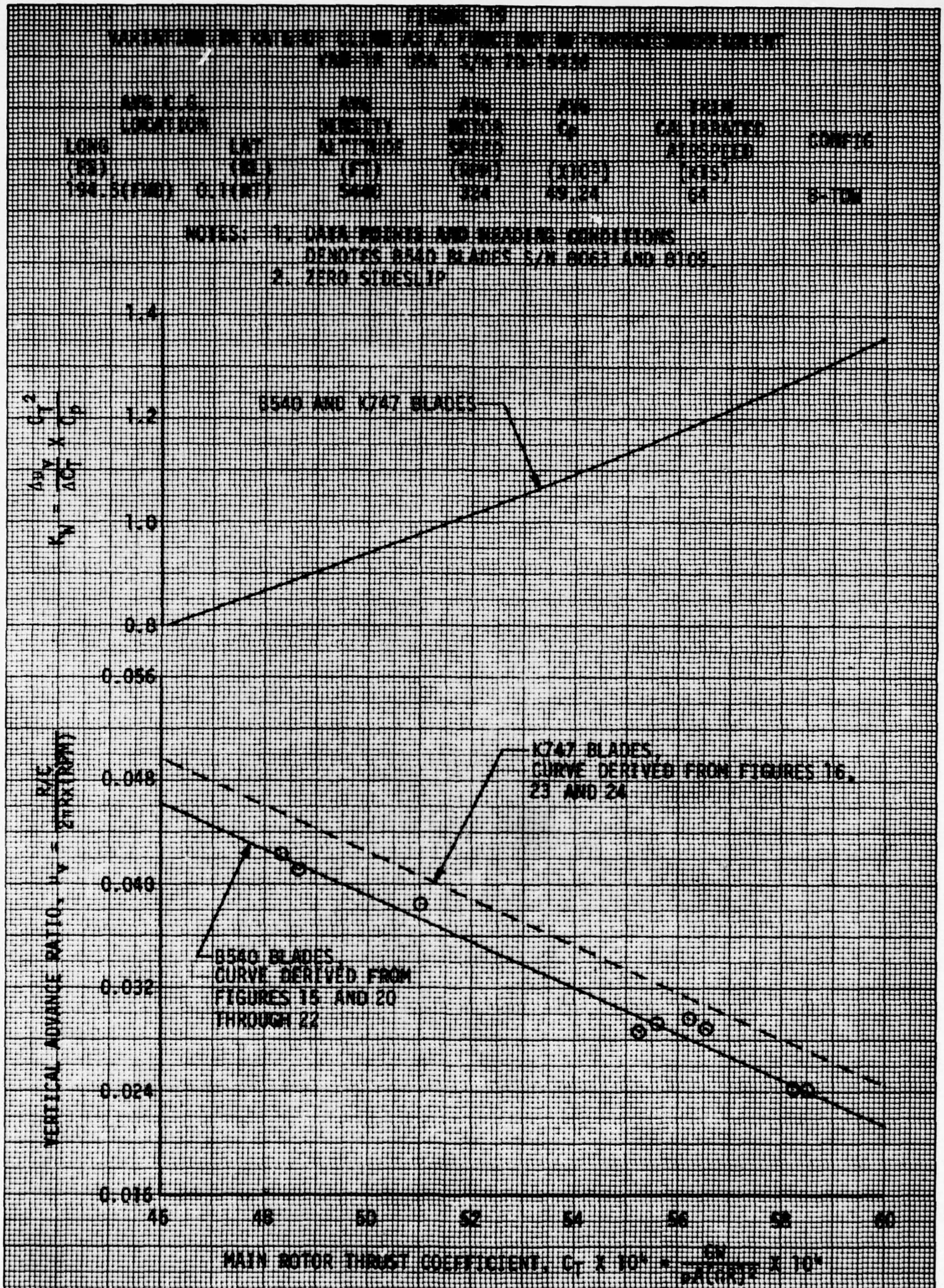


FIGURE 18
FORWARD FLIGHT CLIMB PERFORMANCE
YAH-1R USA S/N 70-15936
ENGINE T53-L-703 S/N LE 15124Z
K747 BLADES S/N 1005 AND 1009

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	CONFIGURATION
9500	196.2(MID)	0.1(RT)	4800	3.5	321	B-TOW

NOTES: 1. CURVE DERIVED FROM FIGS. 16, 23 AND 24.
2. ENGINE SHP = 1100





LONG
(FS)
LAT
CALIBRATED
AIRSPEED
(KTS)
CONFIG
(X10⁻⁵)
49.24
64
NOTES:
DENOTES B540 BLADES S/N 8063 AND 8109
2. ZERO SIDESLIP
B540 AND K747 BLADES
K747 BLADES, CURVE DERIVED FROM FIGURES 16, 23 AND 24
B540 BLADES, CURVE DERIVED FROM FIGURES 15 AND 20 THROUGH 22
VERTICAL ADVANCE RATIO
MAIN ROTOR THRUST COEFFICIENT
1.4
1.2
1.0
0.8
0.056
0.048
0.040
0.032
0.024
0.016
46
48
50
52
54
56
58
60

FIGURE 20
NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE
YAH-1R USA S/N 70-15936

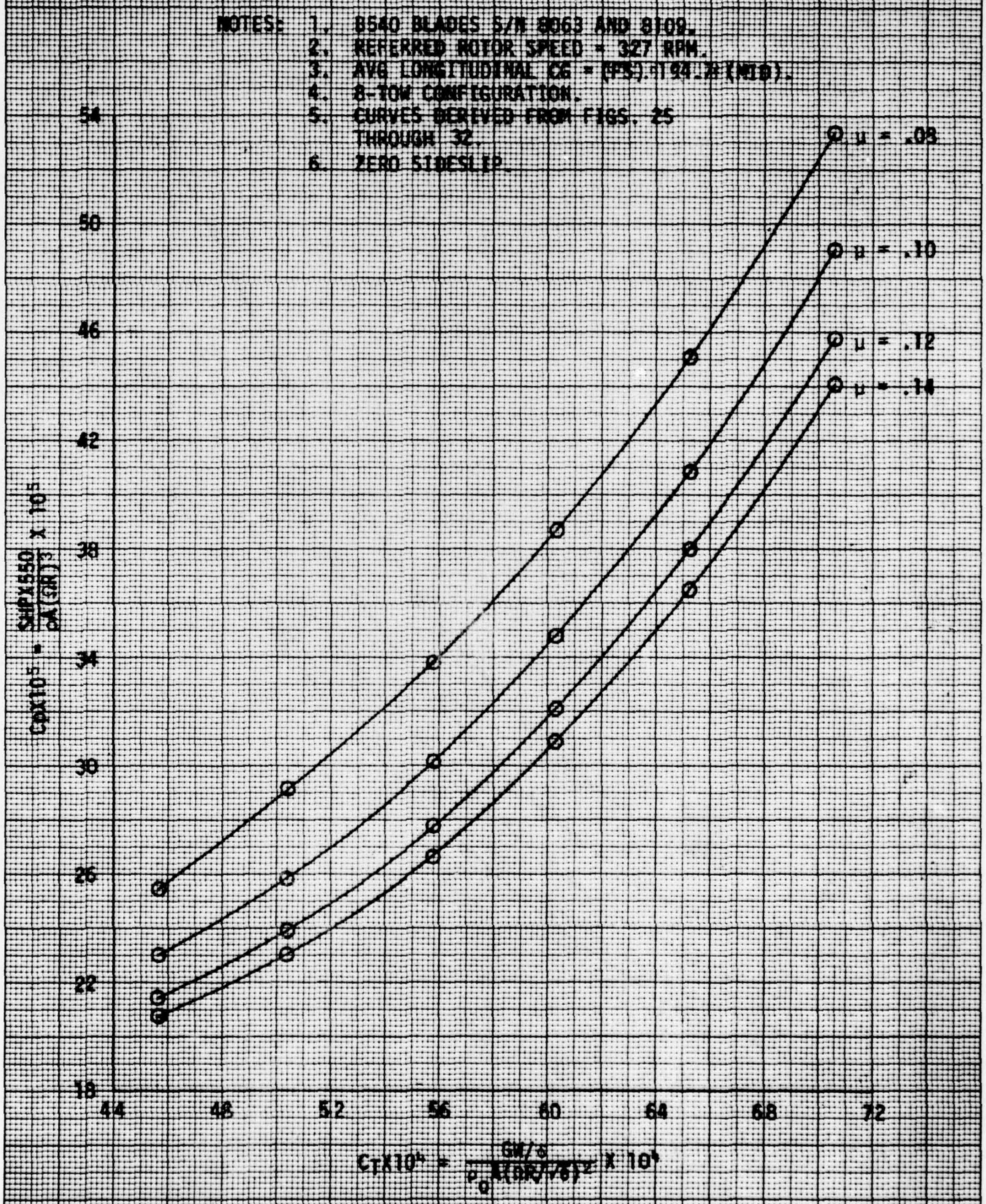
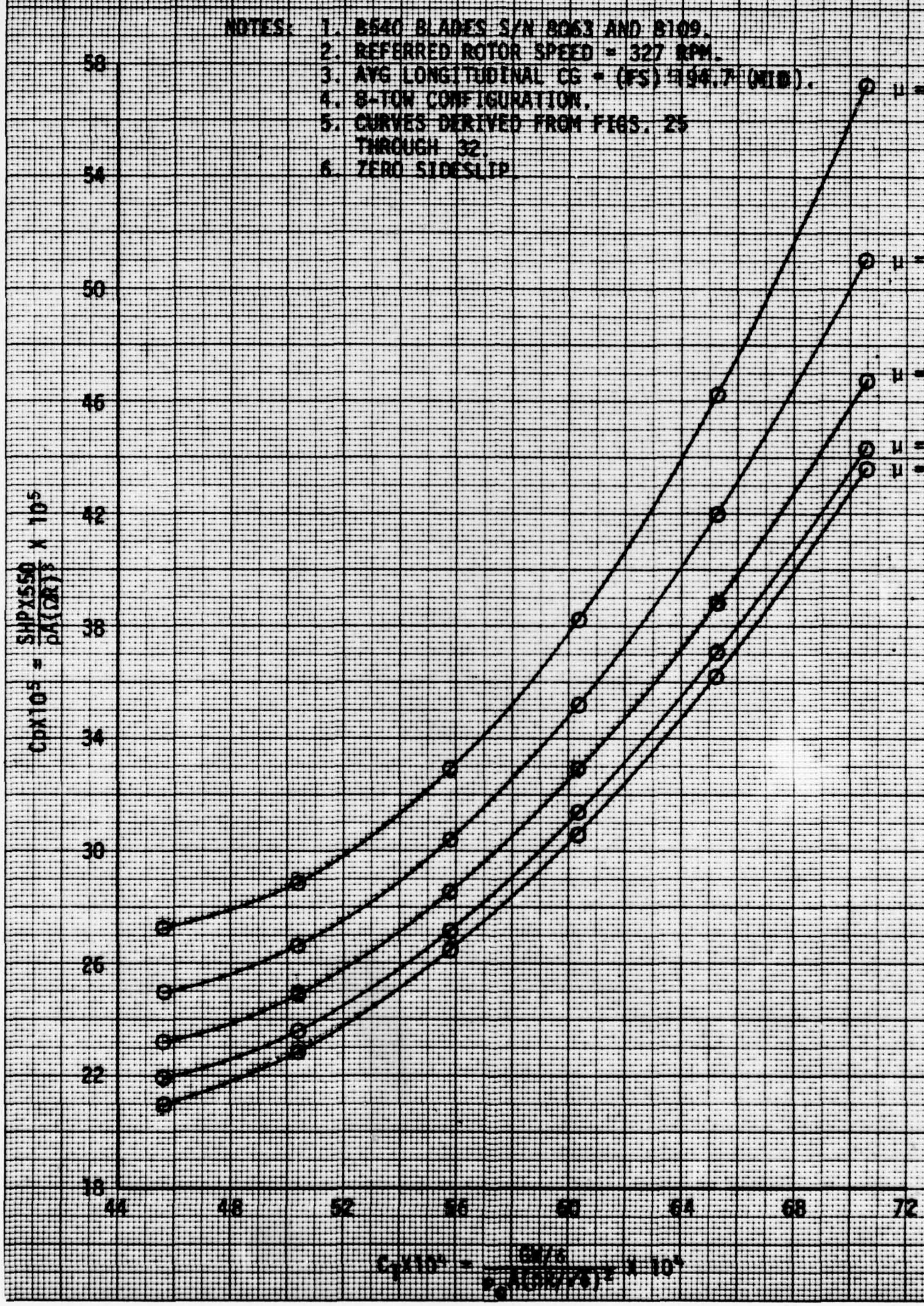


FIGURE 21
NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE
YAH-1R USA S/N 70-15936



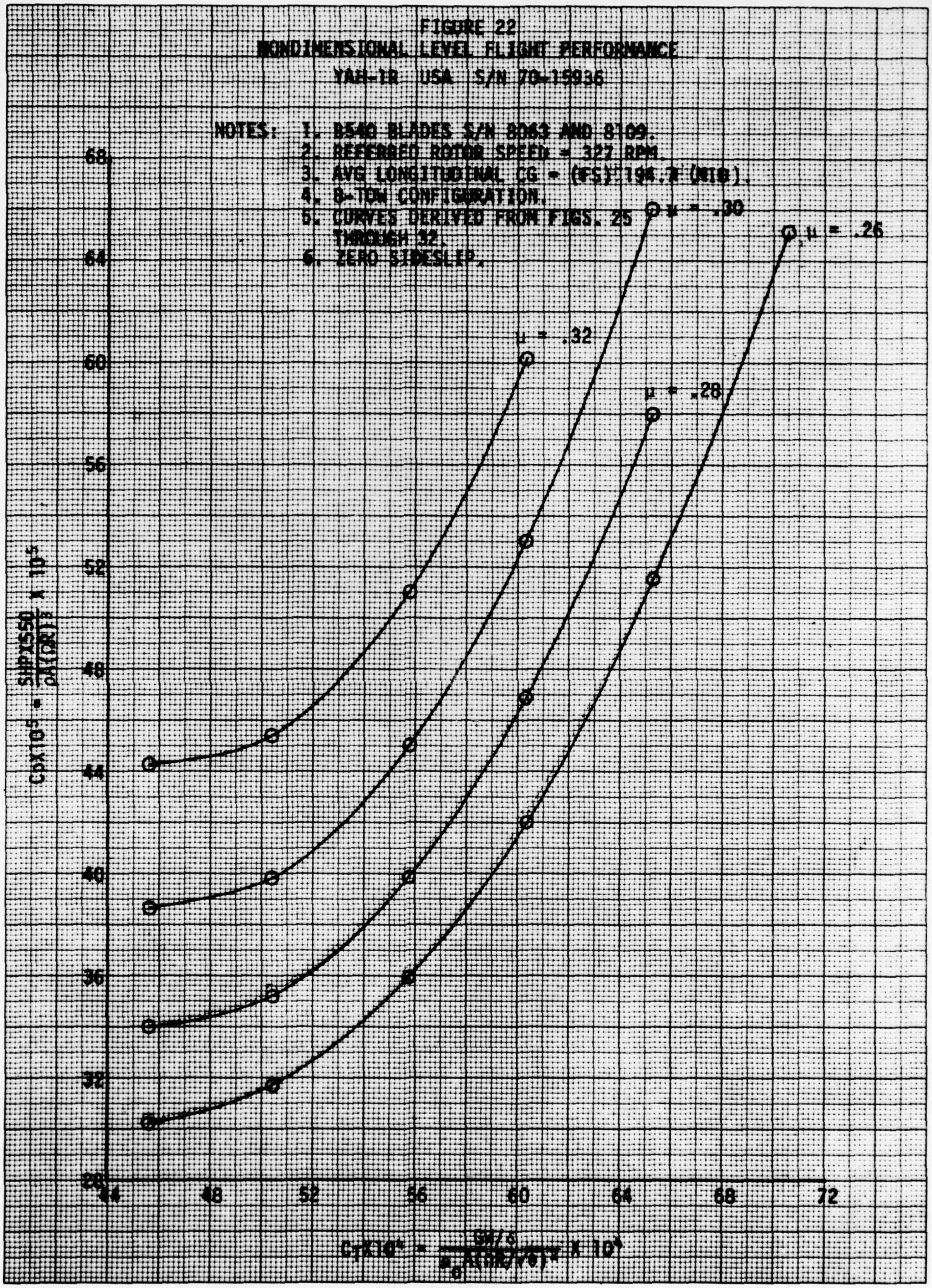
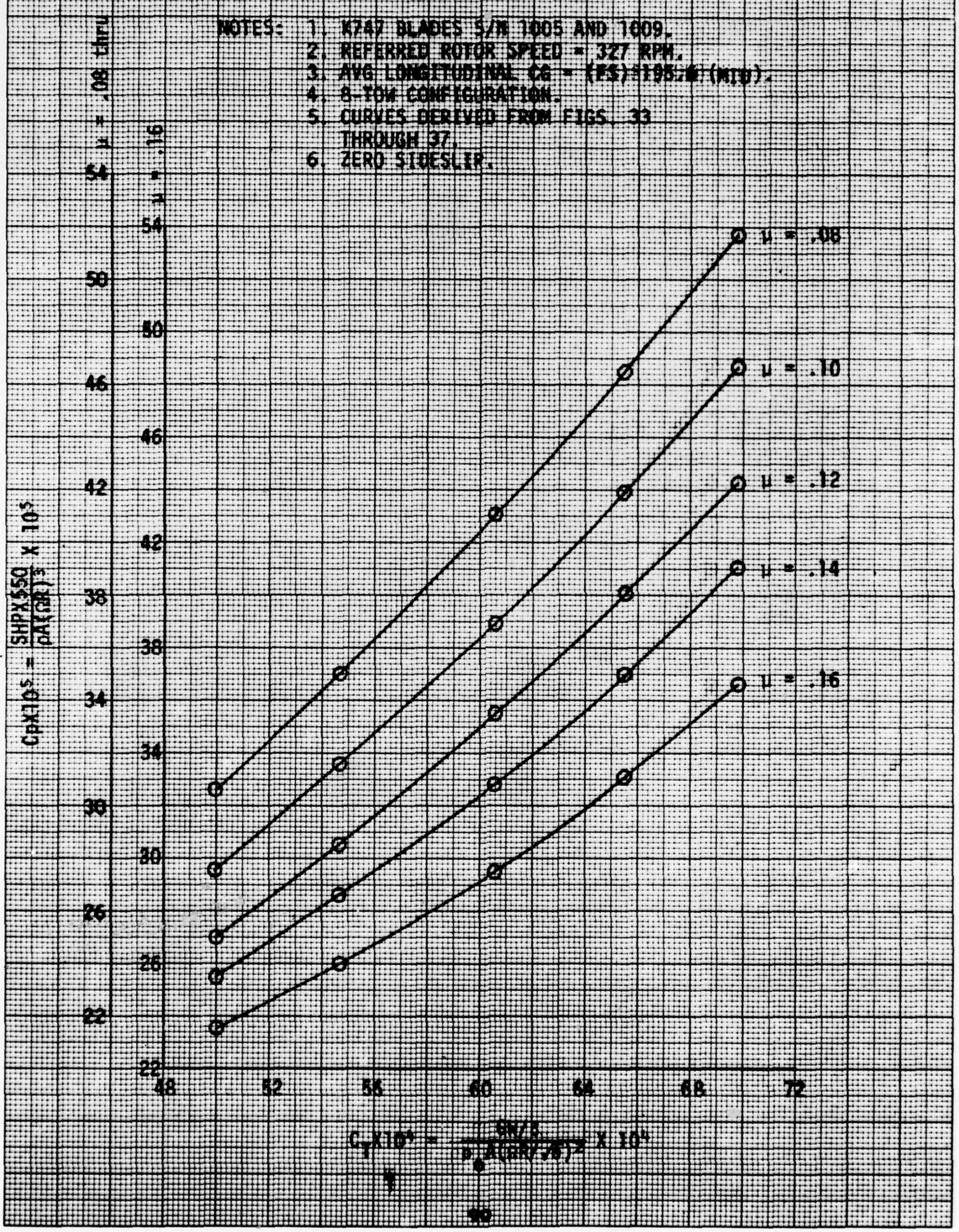


FIGURE 22
NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE
YAH-1R USA S/N 70-15936
NOTES: 1. B540 BLADES S/N 8063 AND 8109.
2. REFERRED ROTOR SPEED = 327 RPM.
3. AVG LONGITUDINAL CG = (FS) 194.7 (MID).
4. B-TOW CONFIGURATION.
5. CURVES DERIVED FROM FIGS. 25 THROUGH 32.
6. ZERO SIDESLIP.
μ = .30
μ = .26
μ = .32
μ = .28
68
64
60
56
52
48
44
40
36
32
28
44
48
52
56
60
64
68
72
$C_P X 10^5 = \frac{SHP X 550}{\rho A (\Omega R)^3} X 10^5$
$C_T X 10^4 = \frac{GW/\delta}{\rho_0 A(\Omega R/\sqrt{\theta})^2} X 10^4$

FIGURE 23
NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE
YAH-1R USA S/N 70-15936



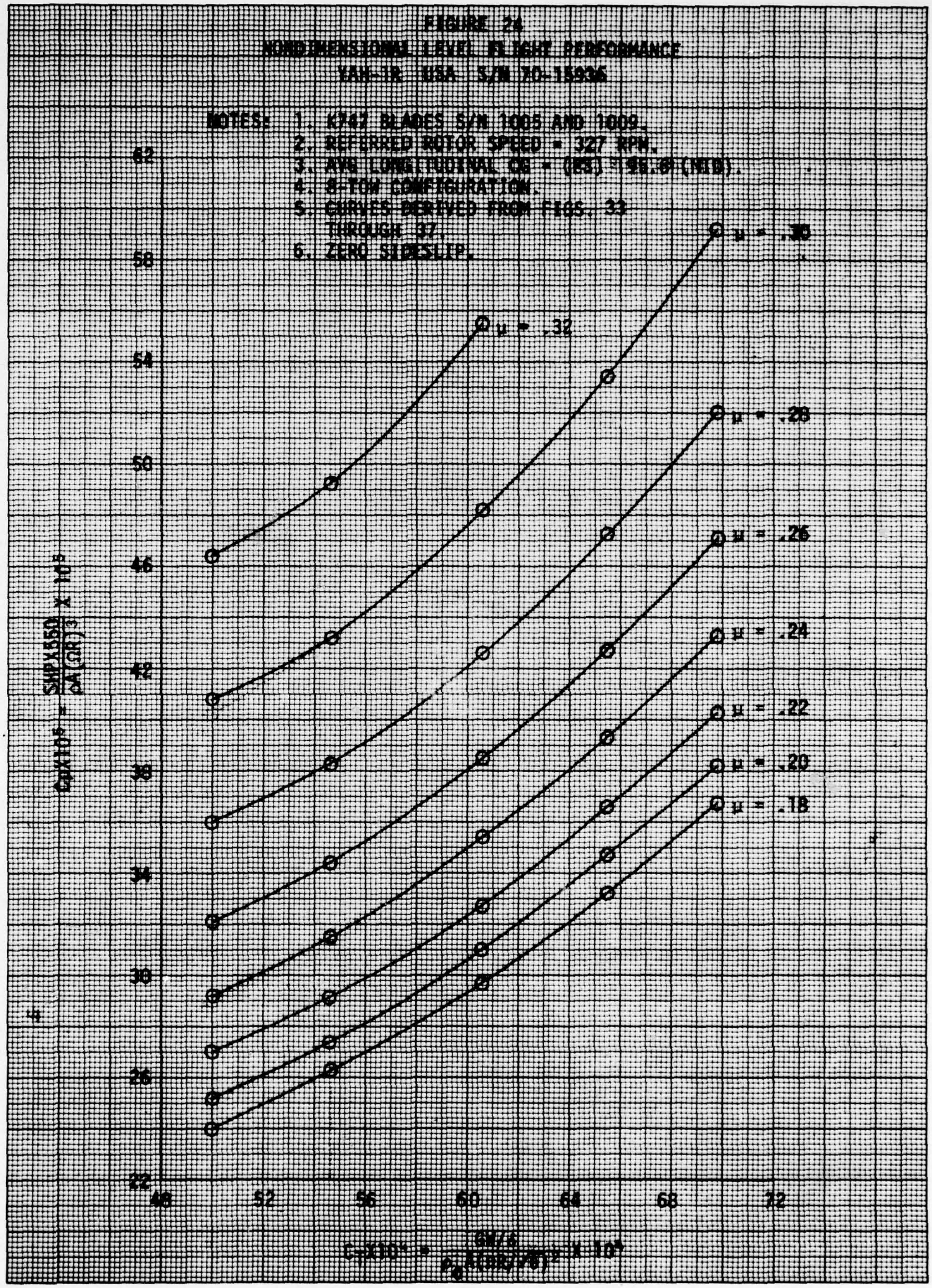


FIGURE 24
NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE
YAH-1R USA S/N 70-15936

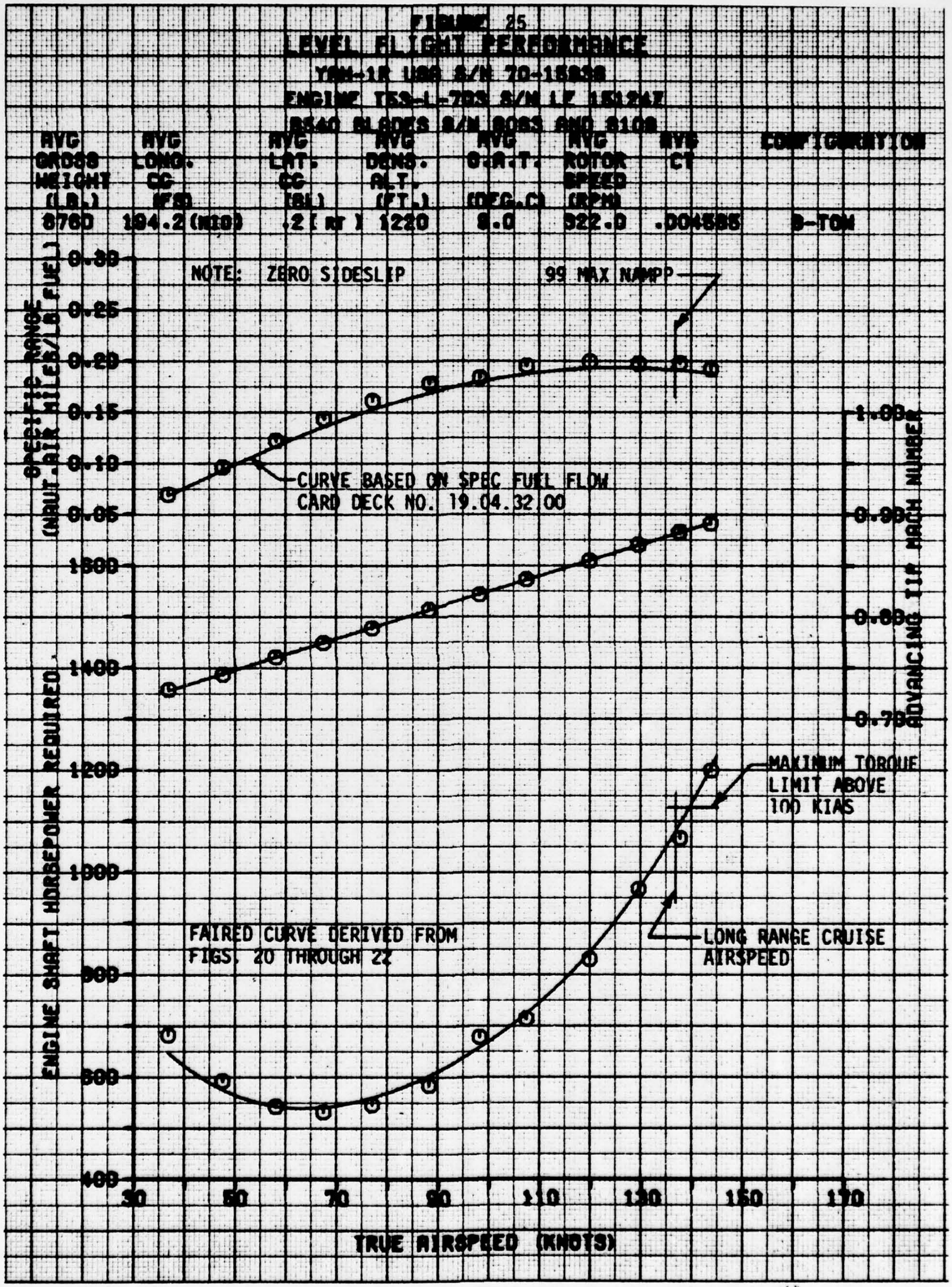


FIGURE 25
LEVEL FLIGHT PERFORMANCE
YAH-1R USA S/N 70-15936
ENGINE T53-L-703 S/N LE 15124Z
B540 BLADES S/N 8063 AND 8108
AVG GROSS WEIGHT (LB.)
AVG LONG. CG (FS)
AVG LAT. CG (BL)
AVG DENS. ALT. (FT.)
AVG O.A.T. (DEG.C)
AVG ROTOR SPEED (RPM)
AVG CT
CONFIGURATION
8760
194.2 (MID)
.2 (RT)
1220
8.0
322.0
.004585
S-TOW
NOTE: ZERO SIDESLIP
99 MAX NAMPP
CURVE BASED ON SPEC FUEL FLOW
CARD DECK NO. 19.04.32 00
SPECIFIC RANGE (NAUT.AIR MILES/LB FUEL)
0.30
0.25
0.20
0.15
0.10
0.05
ADVANCING TIP MACH NUMBER
1.00
0.90
0.80
0.70
ENGINE SHAFT HORSEPOWER REQUIRED
1600
1400
1200
1000
800
600
400
MAXIMUM TORQUE
LIMIT ABOVE
100 KIAS
LONG RANGE CRUISE
AIRSPEED
FAIRED CURVE DERIVED FROM
FIGS. 20 THROUGH 22
30
50
70
90
110
130
150
170
TRUE AIRSPEED (KNOTS)

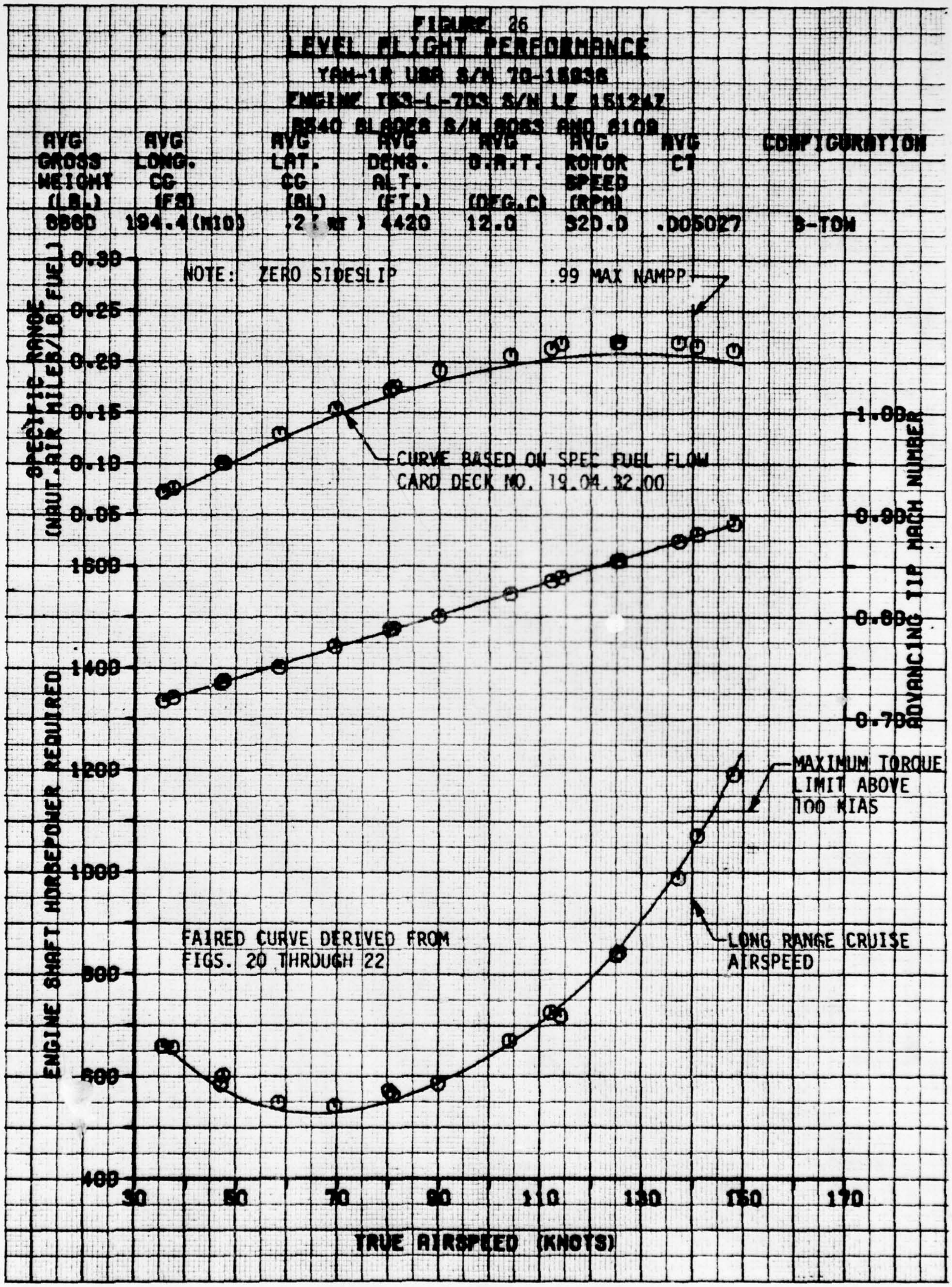


FIGURE 26
LEVEL FLIGHT PERFORMANCE
YAH-1R USA S/N 70-15936
ENGINE T53-L-703 S/N LE 151247
K540 BLADES S/N 8063 AND 8109
AVG GROSS WEIGHT (LB.)
AVG LONG. CG (FS)
AVG LAT. CG (BL)
AVG DENS. ALT. (FT.)
AVG O.A.T. (DEG.C)
AVG ROTOR SPEED (RPM)
AVG CT
CONFIGURATION
8860
194.4 (MID)
.2 (RT)
4420
12.0
320.0
.005027
S-TOW
NOTE: ZERO SIDESLIP
.99 MAX NAMPP
CURVE BASED ON SPEC FUEL FLOW CARD DECK NO. 19.04.32.00
MAXIMUM TORQUE LIMIT ABOVE 100 KIAS
FAIRED CURVE DERIVED FROM FIGS. 20 THROUGH 22
LONG RANGE CRUISE AIRSPEED
SPECIFIC RANGE (NAUT.AIR MILES/LB FUEL)
ENGINE SHAFT HORSEPOWER REQUIRED
ADVANCING TIP MACH NUMBER
TRUE AIRSPEED (KNOTS)
0.30
0.25
0.20
0.15
0.10
0.05
1600
1400
1200
1000
800
600
400
1.00
0.90
0.80
0.70
30
50
70
90
110
130
150
170

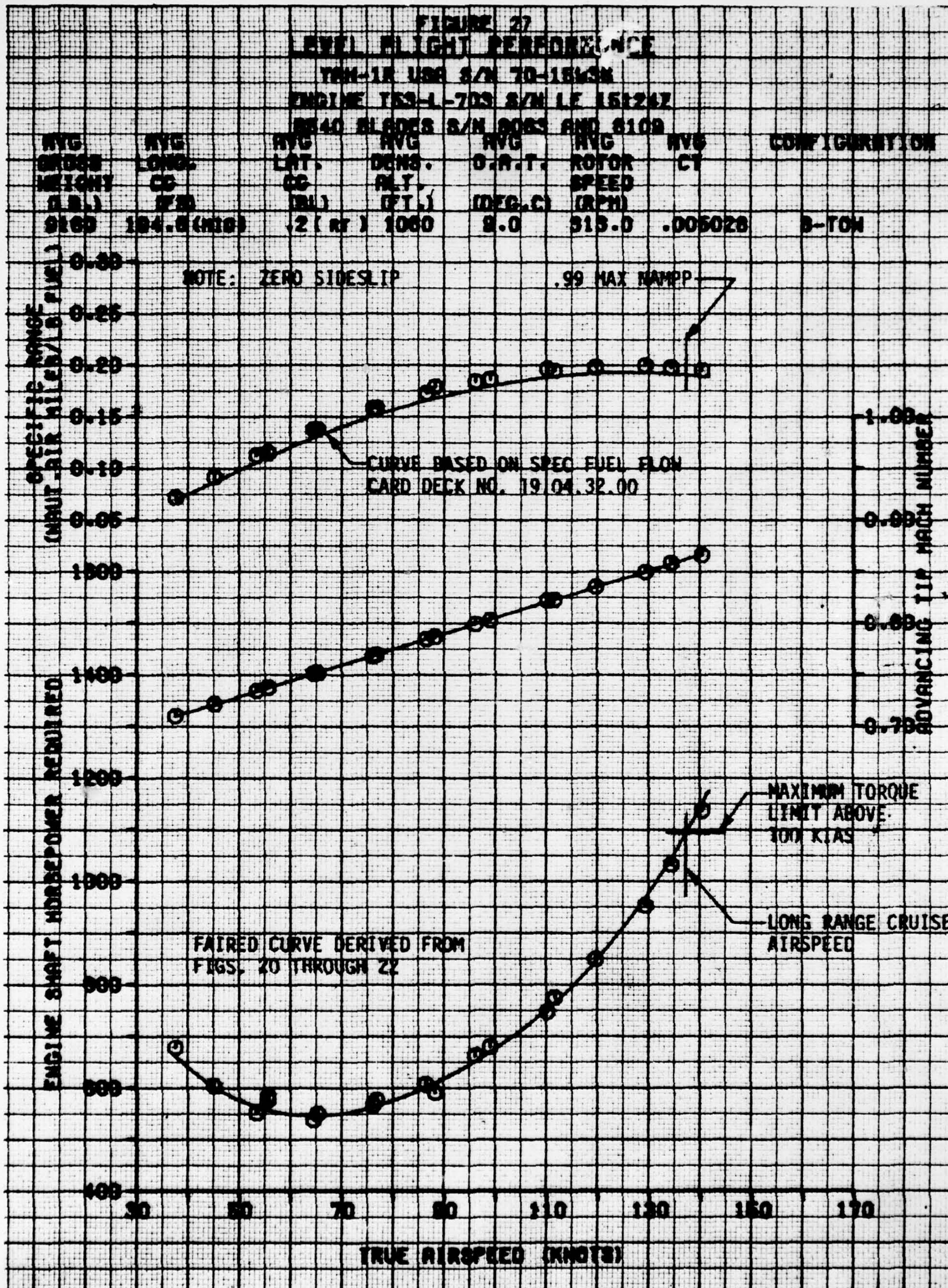


FIGURE 27
LEVEL FLIGHT PERFORMANCE

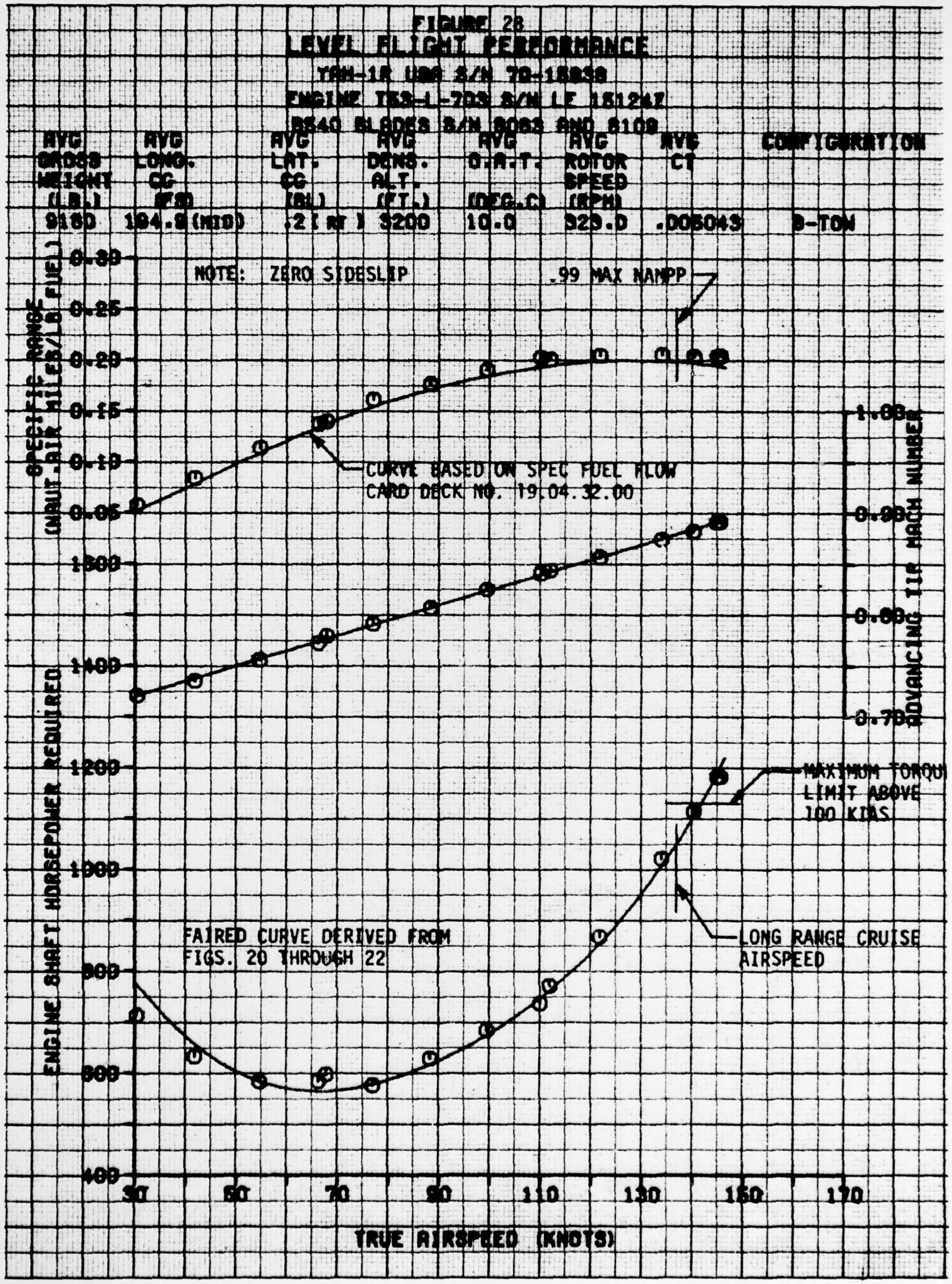
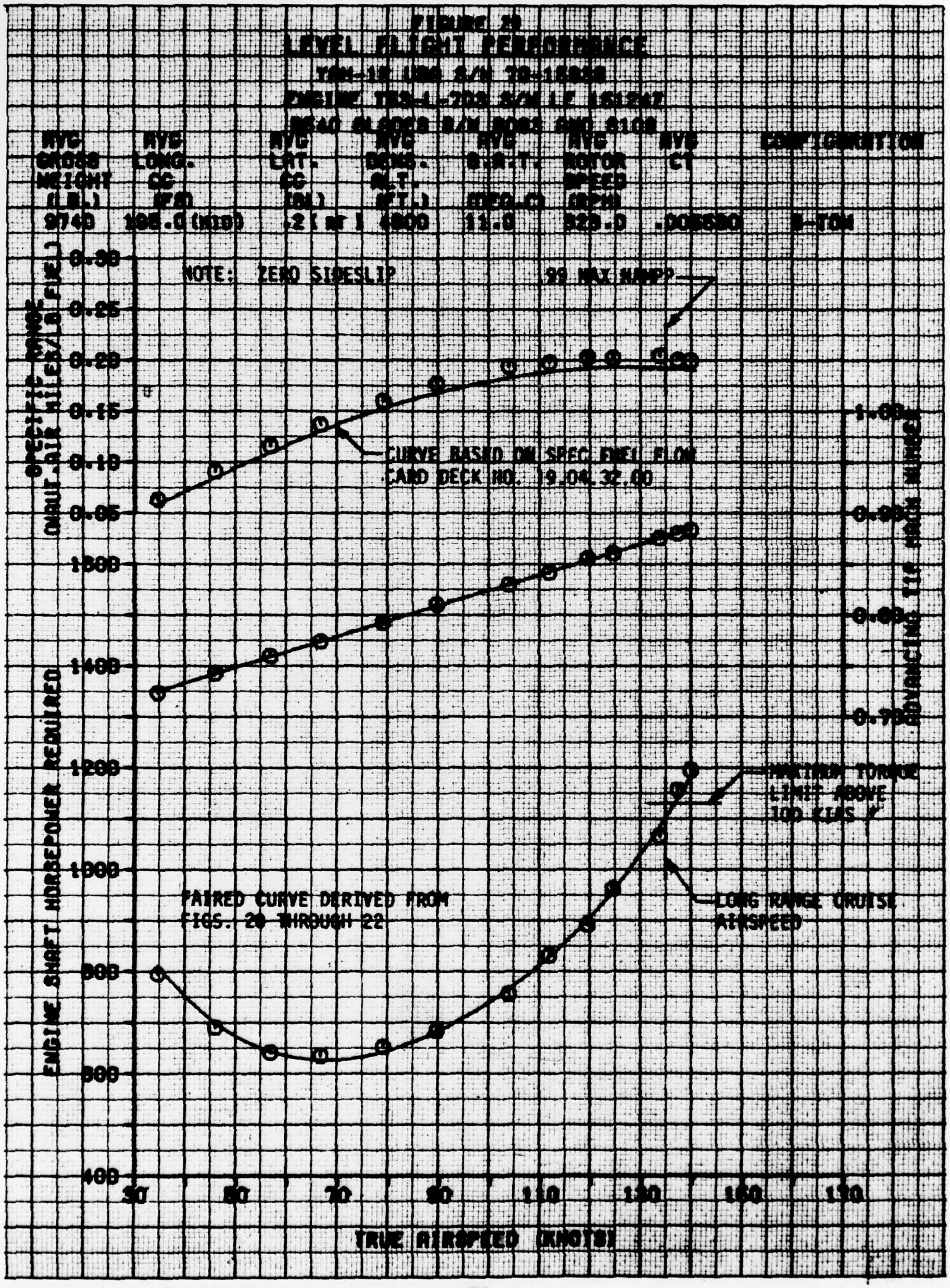


FIGURE 28
LEVEL FLIGHT PERFORMANCE
YAH-1R USA S/N 70-15936
ENGINE T53-L-703 S/N LE 181247
K540 BLADES S/N 8063 AND 8109
AVG GROSS WEIGHT (LB.)
AVG LONG. CG (FS)
AVG LAT. CG (BL)
AVG DENS. ALT. (FT.)
AVG O.A.T. (DEG.C)
AVG ROTOR SPEED (RPM)
AVG CT
CONFIGURATION
9180
194.8 (MID)
.2 (RT)
5200
10.0
323.0
.005043
B-TOW
NOTE: ZERO SIDESLIP
.99 MAX NANPP
SPECIFIC RANGE (NAUT. AIR MILES/LB FUEL)
0.30
0.25
0.20
0.15
0.10
0.05
CURVE BASED ON SPEC FUEL FLOW CARD DECK NO. 19.04.32.00
ADVANCING TIP MACH NUMBER
1.00
0.90
0.80
0.70
ENGINE SHAFT HORSEPOWER REQUIRED
1600
1400
1200
1000
800
600
400
MAXIMUM TORQUE LIMIT ABOVE 100 KIAS
LONG RANGE CRUISE AIRSPEED
FAIRED CURVE DERIVED FROM FIGS. 20 THROUGH 22
30
50
70
90
110
130
150
170
TRUE AIRSPEED (KNOTS)



LEVEL FLIGHT PERFORMANCE
AVG GROSS WEIGHT (LB.)
AVG LONG. CG
AVG LAT. CG
AVG DENS. ALT. (FT.)
AVG ROTOR SPEED (RPM)
AVG CT
CONFIGURATION
9740
4800
11.0
NOTE: ZERO SIDESLIP
CURVE BASED ON SPEC FUEL FLOW
CARD DECK NO. 19.04.32.00
FAIRED CURVE DERIVED FROM
FIGS. 20 THROUGH 22
LONG RANGE CRUISE
AIRSPEED
ENGINE SHAFT HORSEPOWER REQUIRED
TRUE AIRSPEED (KNOTS)

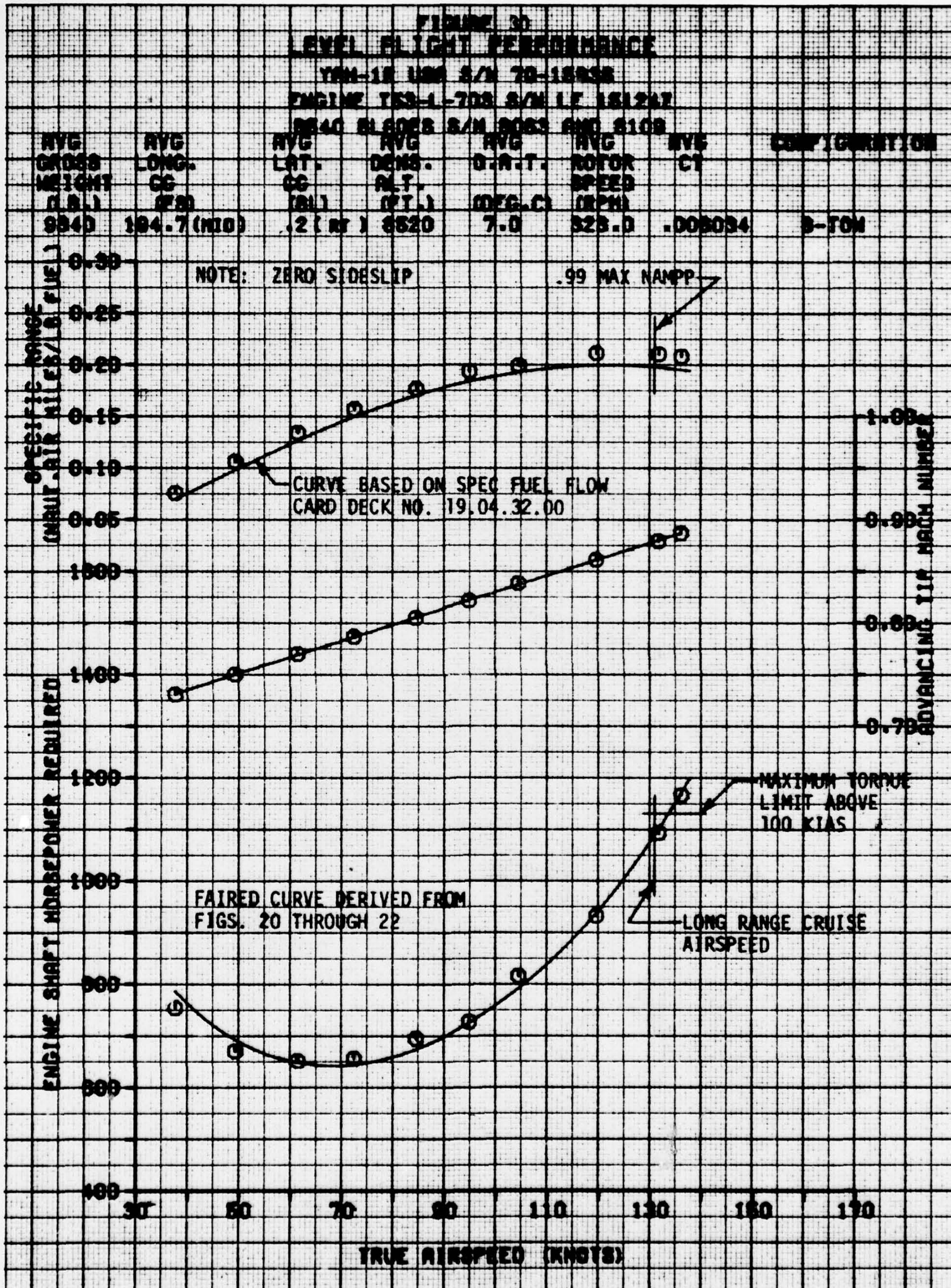
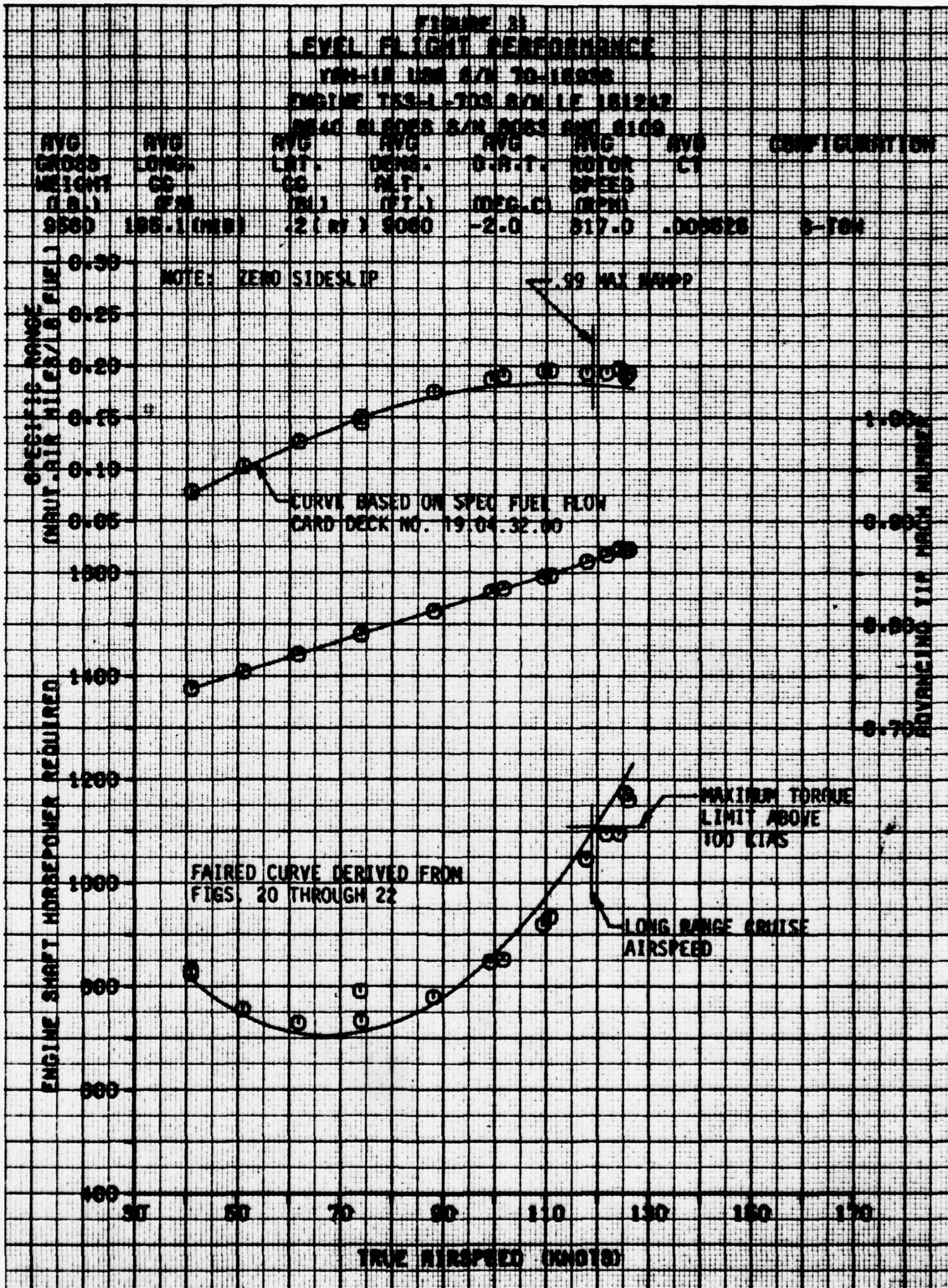


FIGURE 30
LEVEL FLIGHT PERFORMANCE
AVG GROSS WEIGHT (LB) 9840
AVG LONG. CG (FS) 194.7 (MID)
AVG LAT. CG (BL)
AVG DENS. ALT. (FT.) 8520
AVG O.A.T. (DEG.C) 7.0
AVG ROTOR SPEED (RPM)
AVG CT
CONFIGURATION
NOTE: ZERO SIDESLIP
.99 MAX NAMPP
SPECIFIC RANGE (NAUT.AIR MILES/LB FUEL)
0.30
0.25
0.20
0.15
0.10
0.05
CURVE BASED ON SPEC FUEL FLOW CARD DECK NO. 19.04.32.00
ADVANCING TIP MACH NUMBER
1.00
0.90
0.80
0.70
ENGINE SHAFT HORSEPOWER REQUIRED
1400
1200
1000
800
400
MAXIMUM TORQUE LIMIT ABOVE 100 KIAS
FAIRED CURVE DERIVED FROM FIGS. 20 THROUGH 22
LONG RANGE CRUISE AIRSPEED
30
50
70
110
130
170
TRUE AIRSPEED (KNOTS)



LEVEL FLIGHT PERFORMANCE
ENGINE
AVG
GROSS
WEIGHT
AVG
LONG.
CG
AVG
LAT.
CG
AVG
DENS.
ALT.
(FT.)
AVG
O.A.T.
(DEG.C)
AVG
ROTOR
SPEED
(RPM)
AVG
CT
CONFIGURATION
9560
9060
-2.0
317.0
NOTE: ZERO SIDESLIP
.99 MAX MAHPP
SPECIFIC RANGE (NAUT.AIR MILES/LB FUEL)
0.30
0.25
0.20
0.15
0.10
0.05
CURVE BASED ON SPEC FUEL FLOW
CARD DECK NO. 19.04.32.00
ADVANCING TIP MACH NUMBER
1.00
0.90
0.80
0.70
ENGINE SHAFT HORSEPOWER REQUIRED
1600
1400
1200
1000
800
600
400
MAXIMUM TORQUE
LIMIT ABOVE
100 KIAS
FAIRED CURVE DERIVED FROM
FIGS. 20 THROUGH 22
LONG RANGE CRUISE
AIRSPEED
30
50
70
90
110
130
150
170
TRUE AIRSPEED (KNOTS)

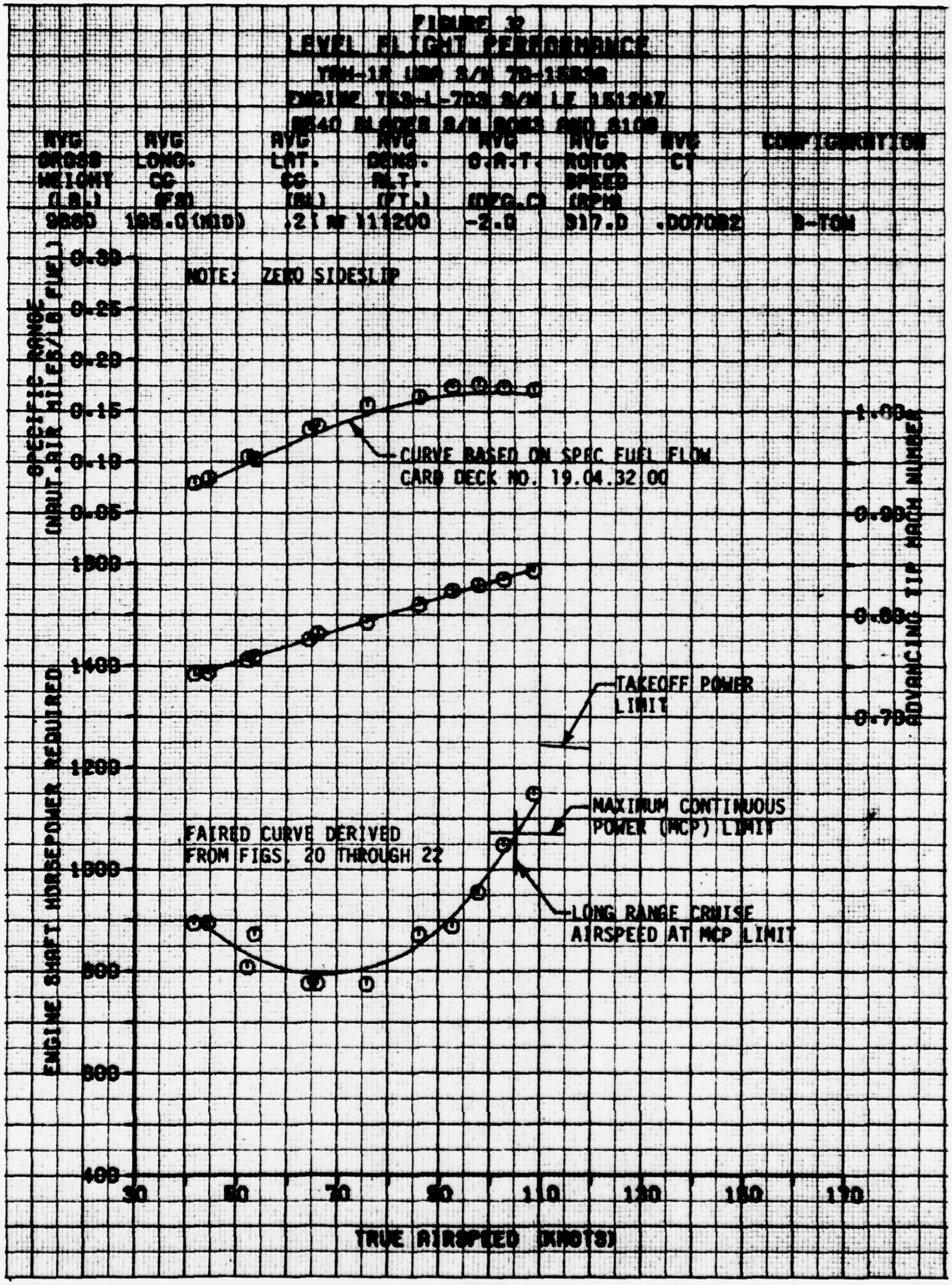


FIGURE 32
LEVEL FLIGHT PERFORMANCE
NOTE: ZERO SIDESLIP
CURVE BASED ON SPEC FUEL FLOW
CARD DECK NO. 19.04.32.00
TAKEOFF POWER LIMIT
MAXIMUM CONTINUOUS POWER (MCP) LIMIT
FAIRED CURVE DERIVED FROM FIGS. 20 THROUGH 22
LONG RANGE CRUISE AIRSPEED AT MCP LIMIT
SPECIFIC RANGE (NAUT. AIR MILES/LB FUEL)
ENGINE SHAFT HORSEPOWER REQUIRED
ADVANCING TIP MACH NUMBER
TRUE AIRSPEED (KNOTS)

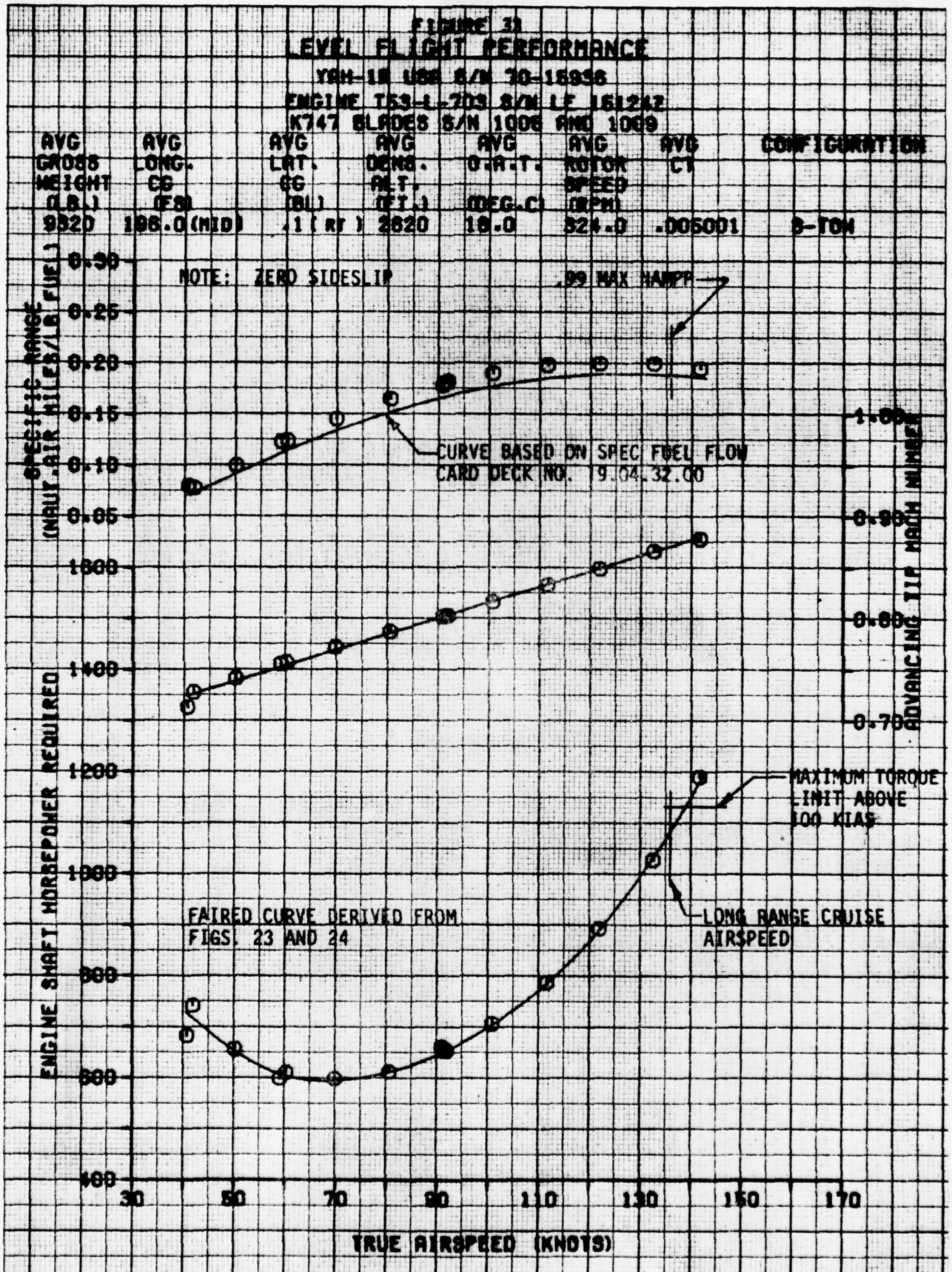


FIGURE 33
LEVEL FLIGHT PERFORMANCE

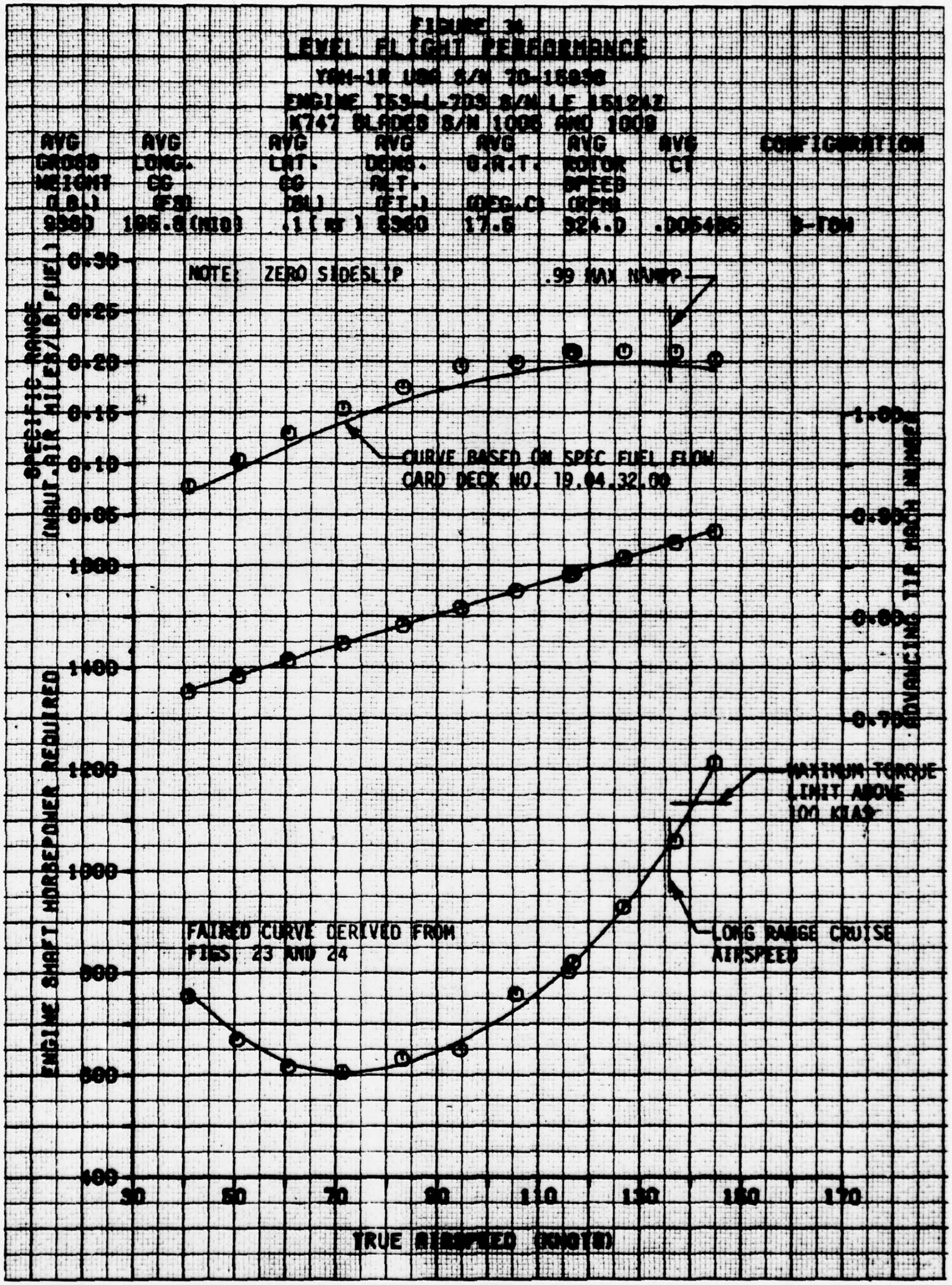
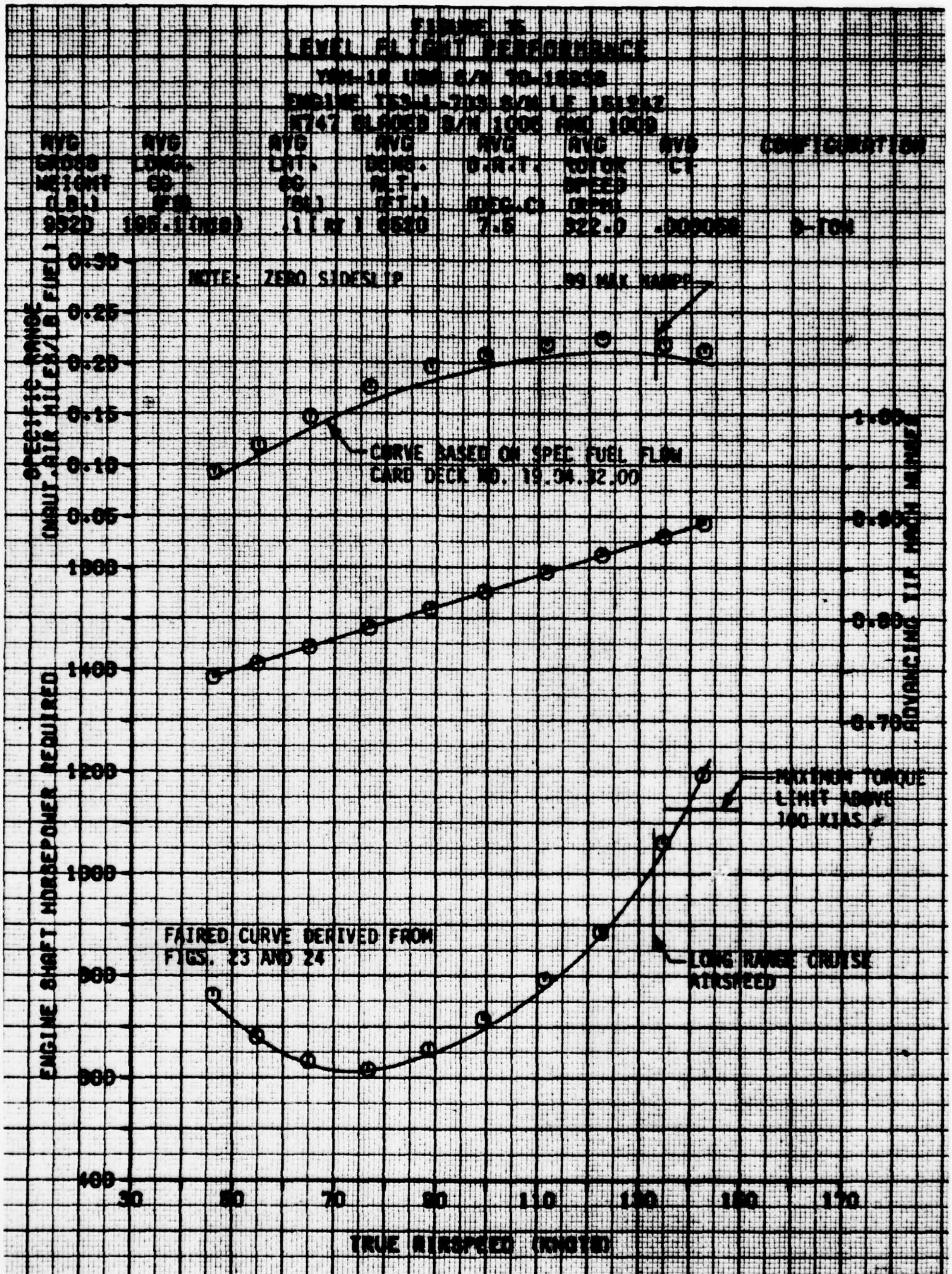


FIGURE 36
LEVEL FLIGHT PERFORMANCE
YAH-1R USA S/N 70-15936
ENGINE T53-L-703 S/N LE 151242
K747 BLADES S/N 1006 AND 1009
AVG GROSS WEIGHT (LB.) 9380
AVG LONG. CG (FS) 195.8 (MID)
AVG LAT. CG (BL) .1 (RT)
AVG DENS. ALT. (FT.) 5360
AVG O.A.T. (DEG.C) 17.5
AVG ROTOR SPEED (RPM) 324.0
AVG CT .005405
CONFIGURATION B-TOW
NOTE: ZERO SIDESLIP
.99 MAX NAMPP
CURVE BASED ON SPEC FUEL FLOW CARD DECK NO. 19.04.32.00
MAXIMUM TORQUE LIMIT ABOVE 100 KIAS
LONG RANGE CRUISE AIRSPEED
FAIRED CURVE DERIVED FROM FIGS. 23 AND 24
SPECIFIC RANGE (NAUT.AIR MILES/LB FUEL)
ENGINE SHAFT HORSEPOWER REQUIRED
ADVANCING TIP MACH NUMBER
TRUE AIRSPEED (KNOTS)
0.30
0.25
0.20
0.15
0.10
0.05
1600
1400
1200
1000
800
600
400
1.00
0.90
0.80
0.70
30
50
70
90
110
130
150
170


LEVEL FLIGHT PERFORMANCE
AVG GROSS WEIGHT (LB.)
AVG LONG. CG
AVG LAT. CG
AVG DENS. ALT. (FT.)
AVG ROTOR SPEED
AVG CT
CONFIGURATION
9520
7.6
322.0
NOTE: ZERO SIDESLIP
CURVE BASED ON SPEC FUEL FLOW CARD DECK NO. 19.54.32.00
FAIRED CURVE DERIVED FROM FIGS. 23 AND 24
LONG RANGE CRUISE AIRSPEED
MAXIMUM TORQUE LIMIT ABOVE 100 KIAS
SPECIFIC RANGE
ENGINE SHAFT HORSEPOWER REQUIRED
ADVANCING TIP MACH NUMBER
TRUE AIRSPEED (KNOTS)
0.30
0.25
0.20
0.15
0.10
0.05
1.00
0.70
1200
1000
400
30
70
90
110
170

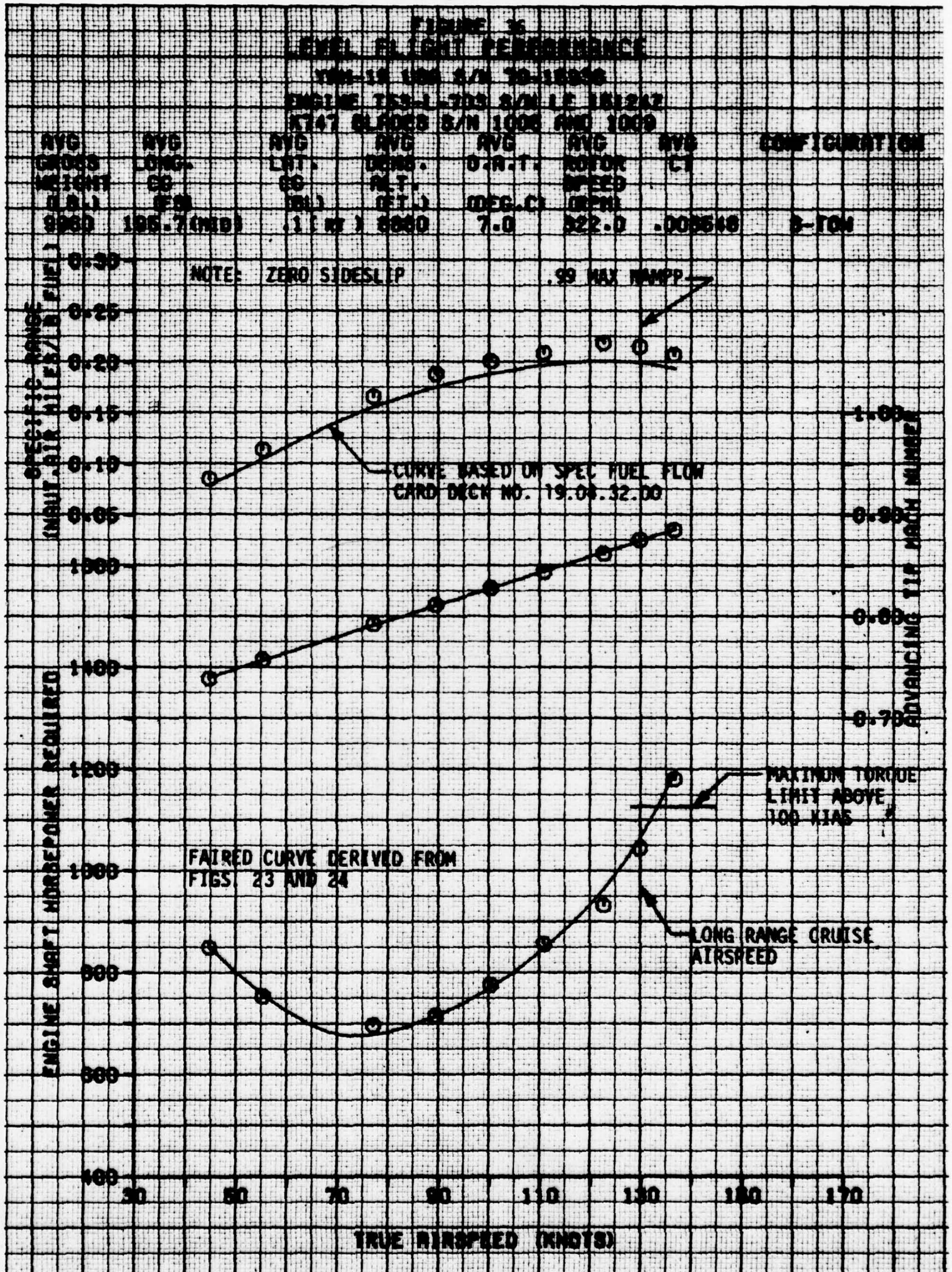
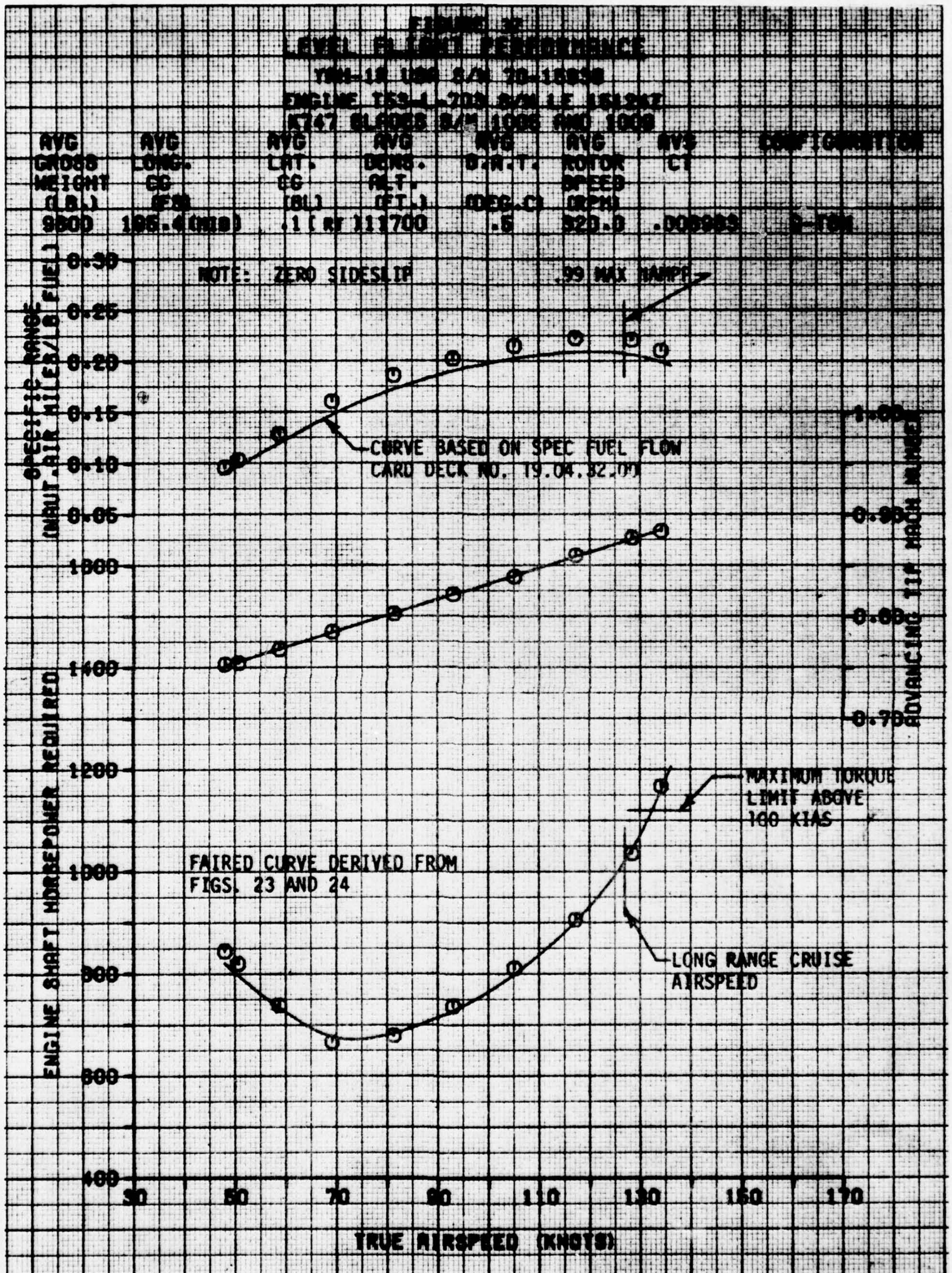


FIGURE 36
LEVEL FLIGHT PERFORMANCE
K747 BLADES S/N 1008 AND 1009
AVG GROSS WEIGHT (LB.)
AVG LONG. CG (FS)
AVG LAT. CG (BL)
AVG DENS. ALT. (FT.)
AVG O.A.T. (DEG.C)
AVG ROTOR SPEED (RPM)
AVG CT
CONFIGURATION
NOTE: ZERO SIDESLIP
.99 MAX MAMPP
CURVE BASED ON SPEC FUEL FLOW
CARD DECK NO. 19.08.32.00
SPECIFIC RANGE (NAUT AIR MILES/LB FUEL)
ADVANCING TIP MACH NUMBER
ENGINE SHAFT HORSEPOWER REQUIRED
MAXIMUM TORQUE LIMIT ABOVE 100 KIAS
FAIRED CURVE DERIVED FROM FIGS. 23 AND 24
LONG RANGE CRUISE AIRSPEED
TRUE AIRSPEED (KNOTS)



LEVEL FLIGHT PERFORMANCE
K747 BLADES S/N 1006 AND 1009
AVG GROSS WEIGHT (LB.) 9800
AVG LONG. CG (FS)
AVG LAT. CG (BL) .1 (RT)
AVG DENS. ALT. (FT.) 11700
AVG O.A.T. (DEG.C) .5
AVG ROTOR SPEED (RPM) 320.0
AVG CT
CONFIGURATION
NOTE: ZERO SIDESLIP
.99 MAX NAMPF
CURVE BASED ON SPEC FUEL FLOW CARD DECK NO. 19.04.32.00
SPECIFIC RANGE (NAUT.AIR MILES/LB FUEL)
ADVANCING TIP MACH NUMBER
FAIRED CURVE DERIVED FROM FIGS. 23 AND 24
MAXIMUM TORQUE LIMIT ABOVE 100 KIAS
LONG RANGE CRUISE AIRSPEED
ENGINE SHAFT HORSEPOWER REQUIRED
TRUE AIRSPEED (KNOTS)

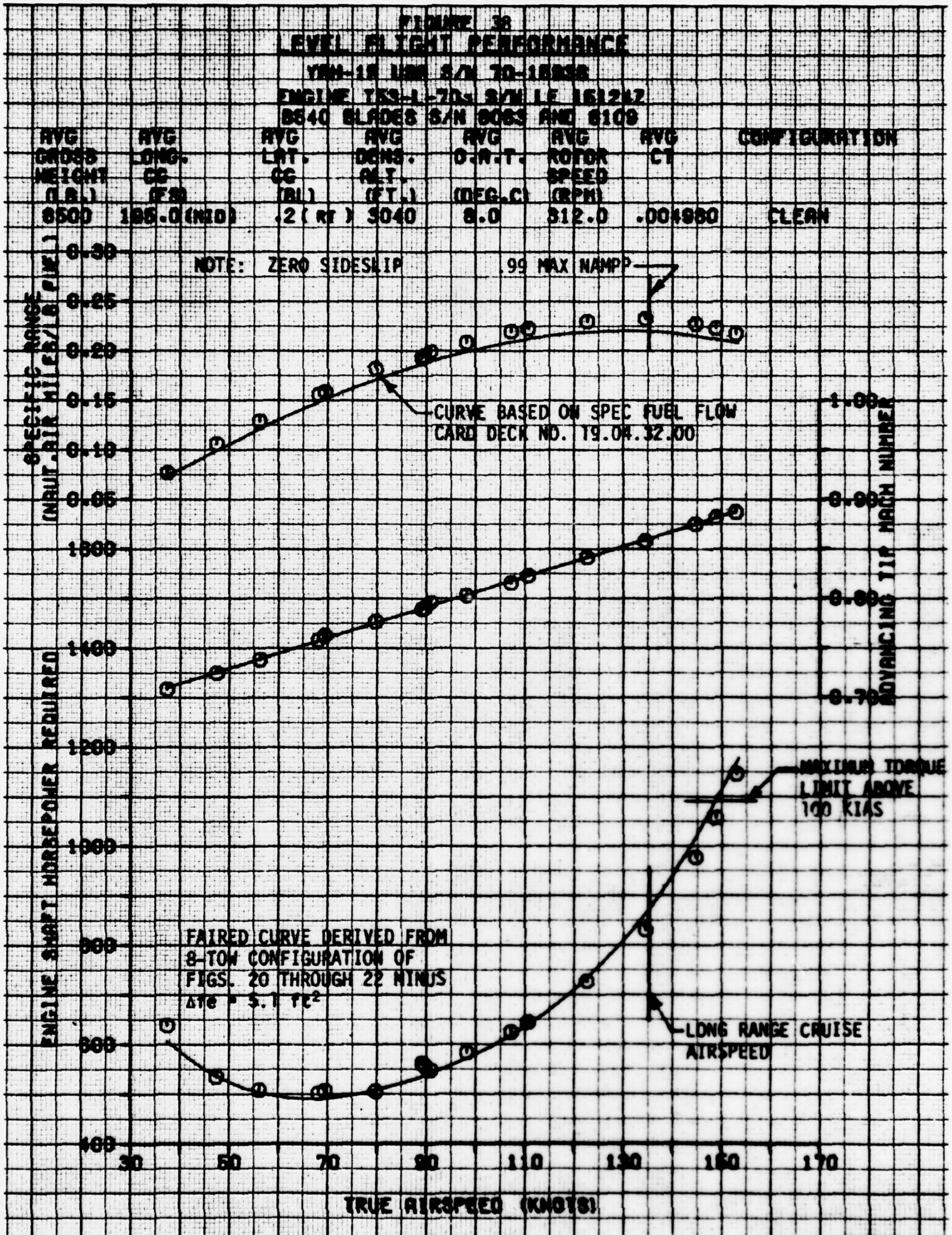
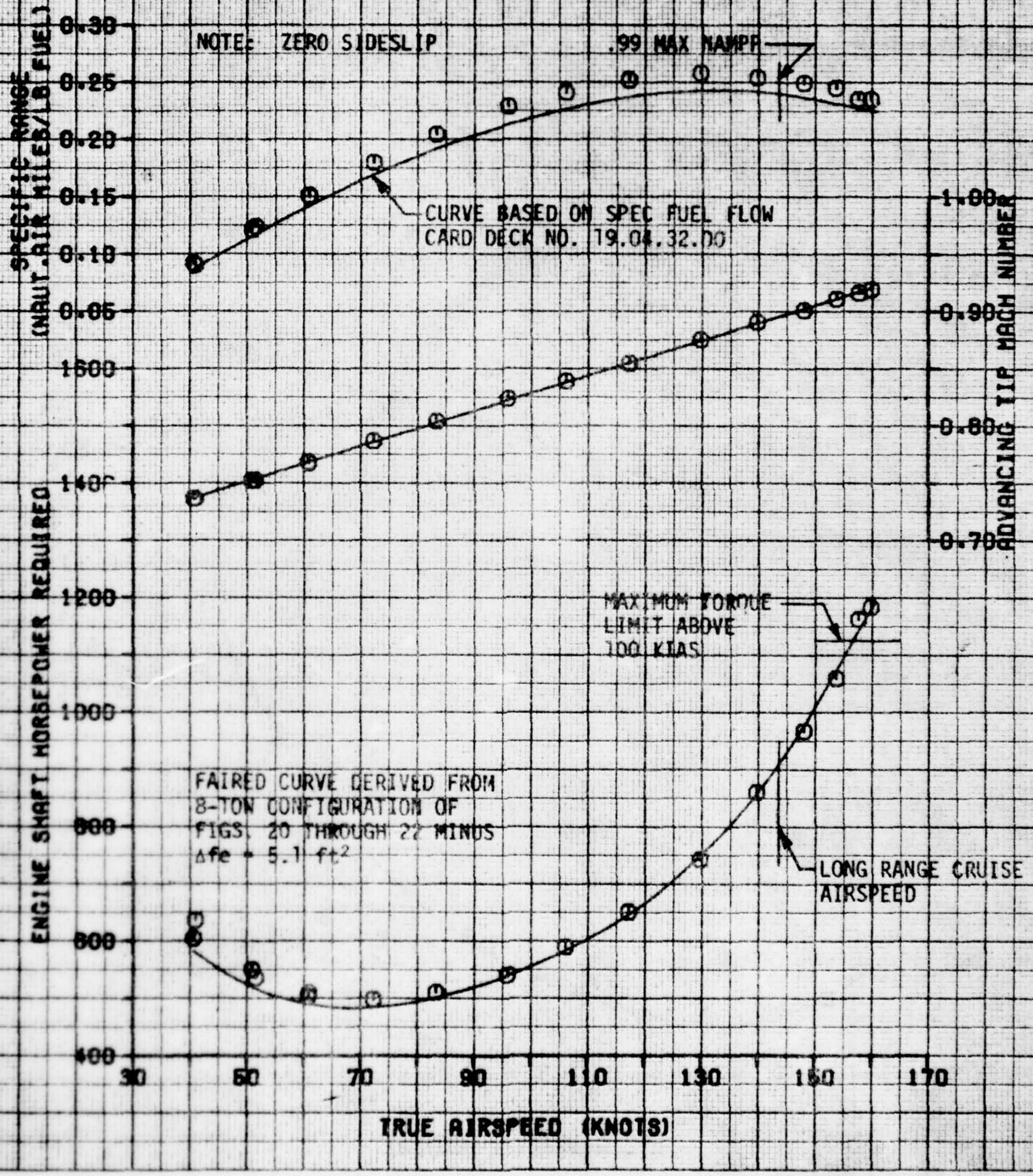


FIGURE 38
LEVEL FLIGHT PERFORMANCE
AVG GROSS WEIGHT (LB.)
AVG LONG. CG (FS)
AVG LAT. CG (BL)
AVG DENS. ALT. (FT.)
AVG O.A.T. (DEG.C)
AVG ROTOR SPEED (RPM)
AVG CT
CONFIGURATION
8500
196.0 (MID)
.2 (RT)
3040
8.0
312.0
.004980
CLEAN
NOTE: ZERO SIDESLIP
.99 MAX NAMPP
CURVE BASED ON SPEC FUEL FLOW CARD DECK NO. 19.04.32.00
SPECIFIC RANGE (NAUT.AIR MILES/LB FUEL)
ADVANCING TIP MACH NUMBER
ENGINE SHAFT HORSEPOWER REQUIRED
MAXIMUM TORQUE LIMIT ABOVE 100 KIAS
FAIRED CURVE DERIVED FROM 8-TOW CONFIGURATION OF FIGS. 20 THROUGH 22 MINUS Δfe = 5.1 ft²
LONG RANGE CRUISE AIRSPEED
TRUE AIRSPEED (KNOTS)

FIGURE 39
LEVEL FLIGHT PERFORMANCE
YAH-1R USA S/N 70-15936
ENGINE T53-L-703 S/N LE 161247
540 BLADES S/N 6063 AND 6109

AVG GROSS WEIGHT (LB.)	AVG LONG. CG (FS)	AVG LAT. CG (BL)	AVG DENS. ALT. (FT.)	AVG O.A.T. (DEG.C)	AVG ROTOR SPEED (RPM)	AVG CT	CONFIGURATION
8100	194.9 (MID)	.2 (RT)	6960	6.5	322.0	.005018	CLEAN



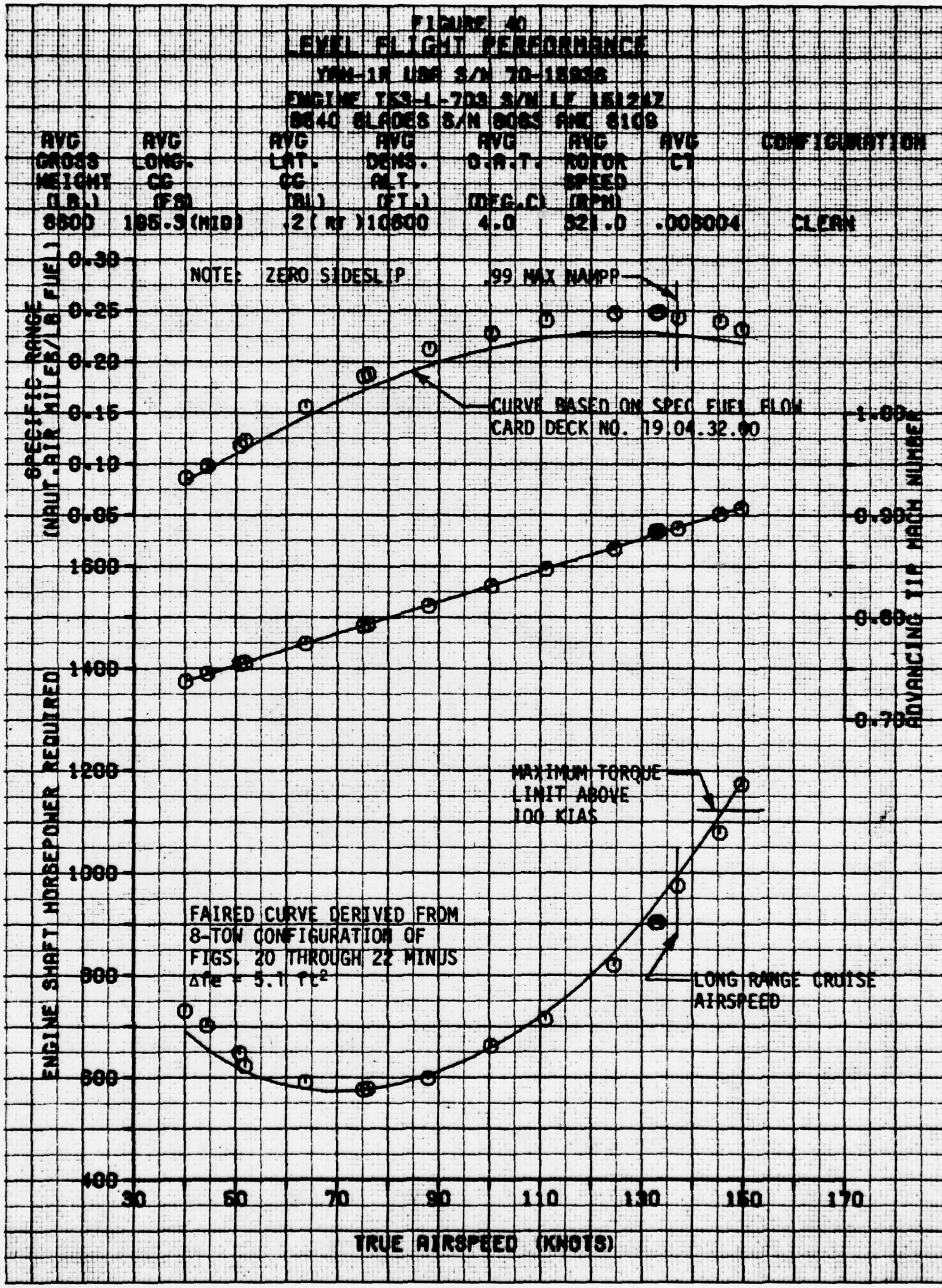


FIGURE 40
LEVEL FLIGHT PERFORMANCE
AVG GROSS WEIGHT (LB.)
AVG LONG. CG (FS)
AVG LAT. CG (BL)
AVG DENS. ALT. (FT.)
AVG O.A.T. (DEG.C)
AVG ROTOR SPEED (RPM)
AVG CT
CONFIGURATION
8500
.2 (RT)
10600
4.0
.006004
CLEAN
NOTE: ZERO SIDESLIP
.99 MAX NAMPP
CURVE BASED ON SPEC FUEL FLOW CARD DECK NO. 19.04.32.00
SPECIFIC RANGE (NAUT. AIR MILES/LB FUEL)
ADVANCING TIP MACH NUMBER
ENGINE SHAFT HORSEPOWER REQUIRED
MAXIMUM TORQUE LIMIT ABOVE 100 KIAS
FAIRED CURVE DERIVED FROM 8-TOW CONFIGURATION OF FIGS. 20 THROUGH 22 MINUS $\Delta fe = 5.1\ ft^2$
LONG RANGE CRUISE AIRSPEED
TRUE AIRSPEED (KNOTS)

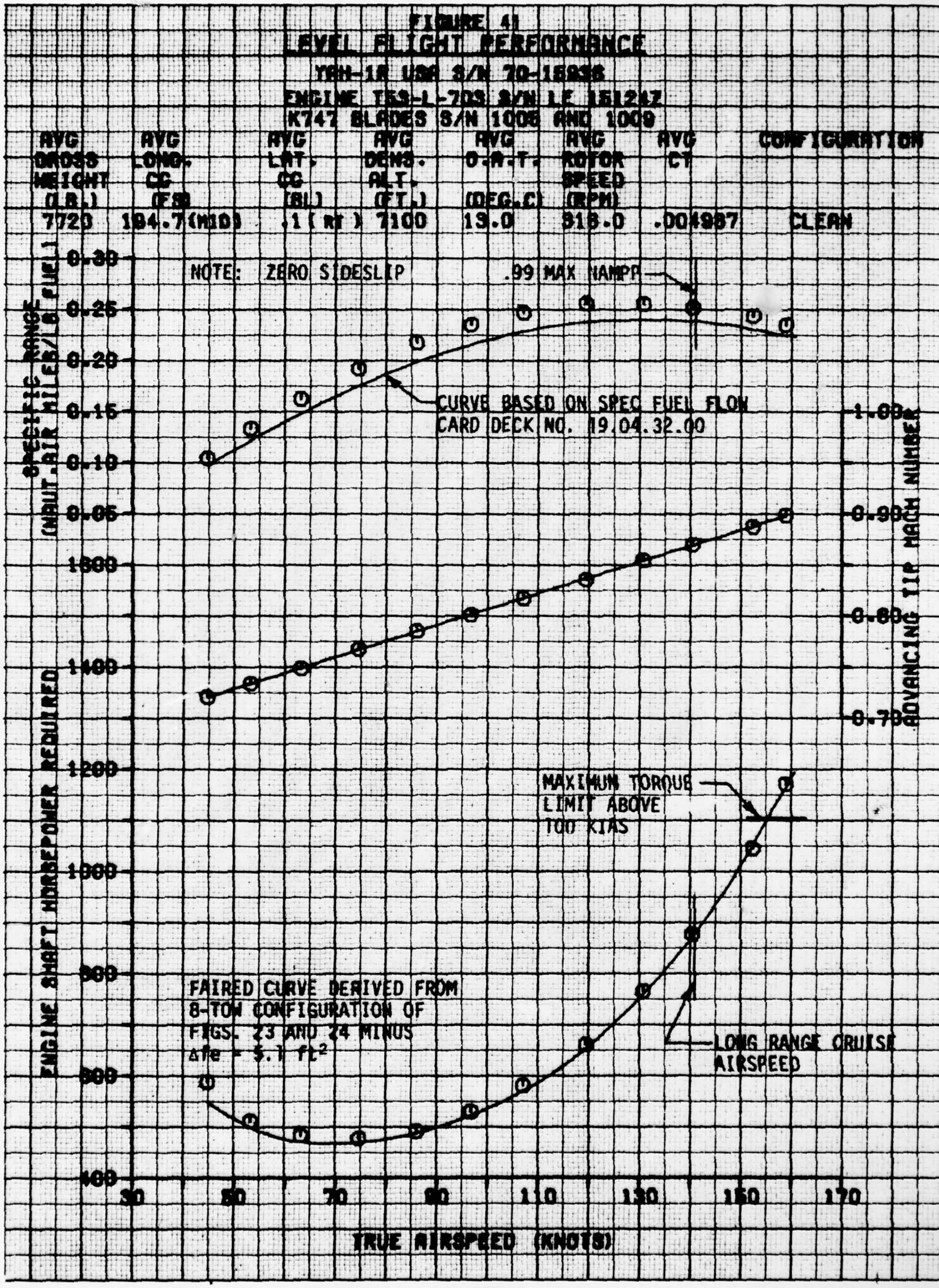


FIGURE 41
LEVEL FLIGHT PERFORMANCE
YAH-1R USA S/N 70-15936
ENGINE T53-L-703 S/N LE 151247
K747 BLADES S/N 1006 AND 1009
AVG GROSS WEIGHT (LB.) 7720
AVG LONG. CG (FS) 194.7(MID)
AVG LAT. CG (BL) .1 (RT)
AVG DENS. ALT. (FT.) 7100
AVG O.A.T. (DEG.C) 13.0
AVG ROTOR SPEED (RPM) 318.0
AVG CT .004987
CONFIGURATION CLEAN
NOTE: ZERO SIDESLIP
.99 MAX NAMPP
CURVE BASED ON SPEC FUEL FLOW CARD DECK NO. 19.04.32.00
SPECIFIC RANGE (NAUT.AIR MILES/LB FUEL)
ADVANCING TIP MACH NUMBER
ENGINE SHAFT HORSEPOWER REQUIRED
MAXIMUM TORQUE LIMIT ABOVE 100 KIAS
FAIRED CURVE DERIVED FROM 8-TOW CONFIGURATION OF FIGS. 23 AND 24 MINUS Δfe = 5.1 ft^2
LONG RANGE CRUISE AIRSPEED
TRUE AIRSPEED (KNOTS)

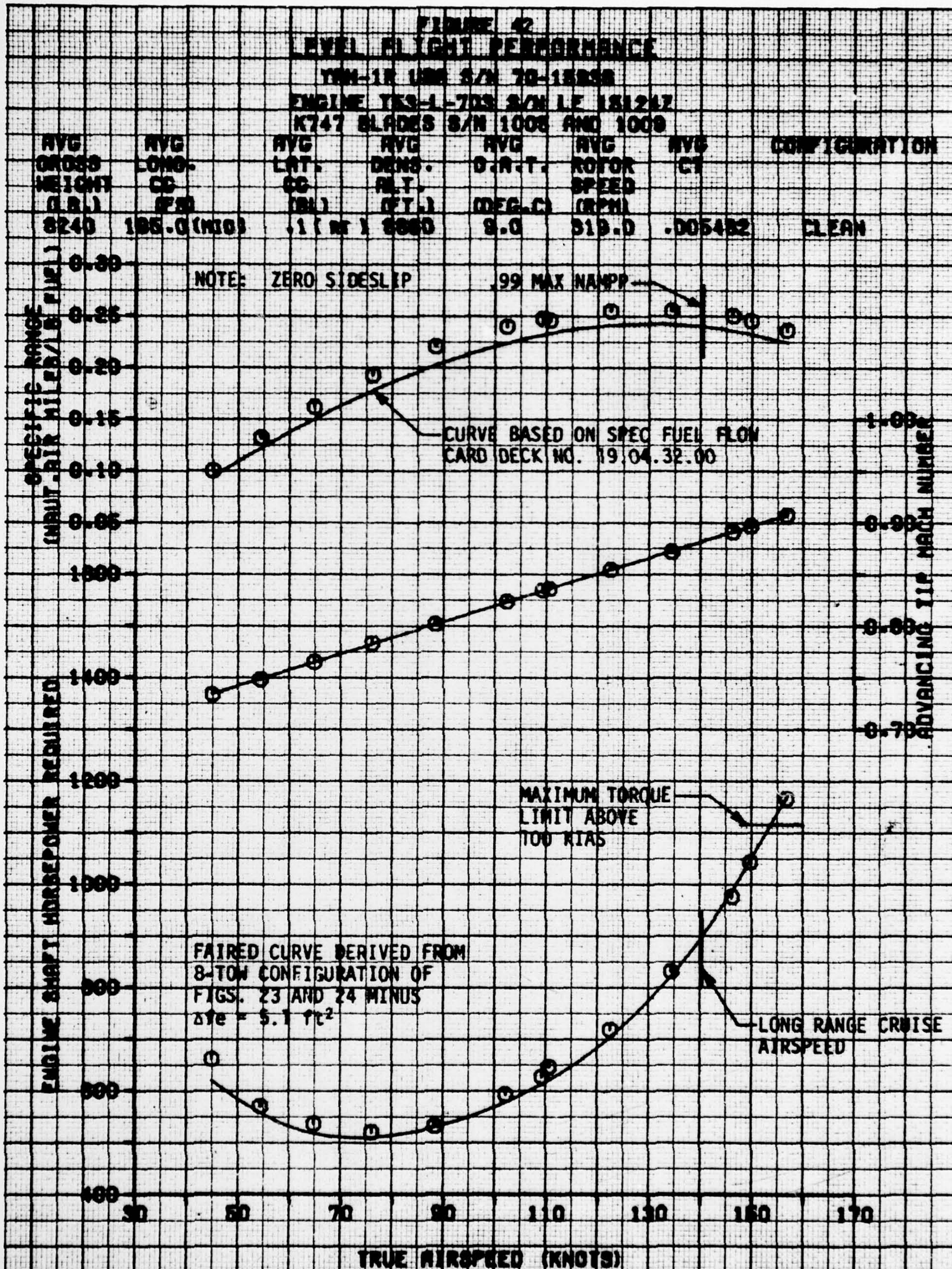
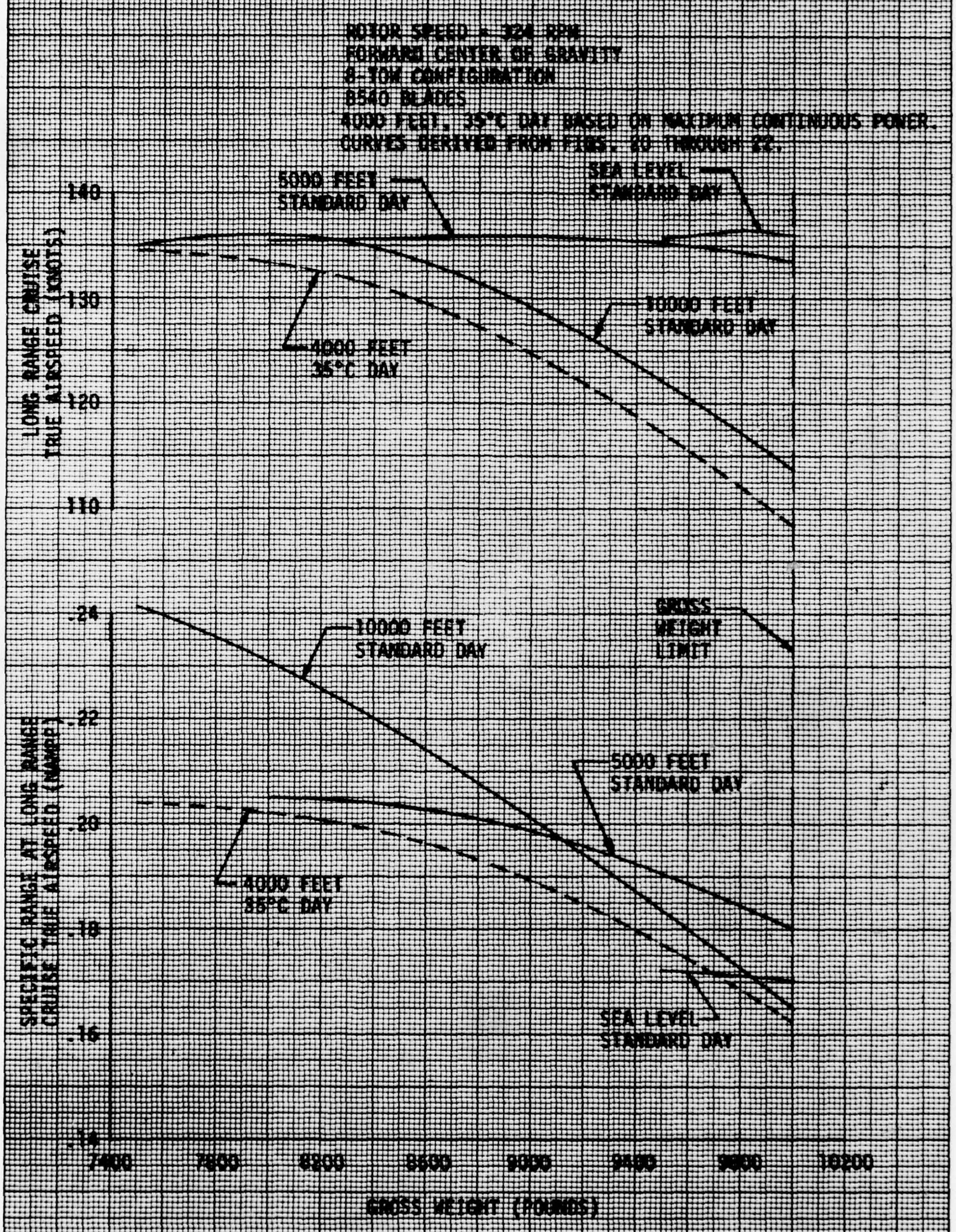


FIGURE 42
LEVEL FLIGHT PERFORMANCE
ENGINE T53-L-703
K747 BLADES S/N 1008 AND 1009
AVG GROSS WEIGHT (LB.)
AVG LONG. CG (FS)
AVG LAT. CG (BL)
AVG DENS. ALT. (FT.)
AVG O.A.T. (DEG.C)
AVG ROTOR SPEED (RPM)
AVG CT
CONFIGURATION
CLEAN
NOTE: ZERO SIDESLIP
.99 MAX NAMPP
CURVE BASED ON SPEC FUEL FLOW
CARD DECK NO. 19.04.32.00
SPECIFIC RANGE (NAUT. AIR MILES/LB FUEL)
0.30
0.25
0.20
0.15
0.10
0.05
ADVANCING TIP MACH NUMBER
1.00
0.90
0.80
0.70
ENGINE SHAFT HORSEPOWER REQUIRED
1600
1400
1200
1000
800
600
400
MAXIMUM TORQUE LIMIT ABOVE 100 KIAS
FAIRED CURVE DERIVED FROM
8-TOW CONFIGURATION OF
FIGS. 23 AND 24 MINUS
Δfe = 5.1 ft²
LONG RANGE CRUISE AIRSPEED
30
50
70
90
110
130
150
170
TRUE AIRSPEED (KNOTS)

FIGURE 43
LONG RANGE SUMMARY
YAH-1R USA S/N 70-15936



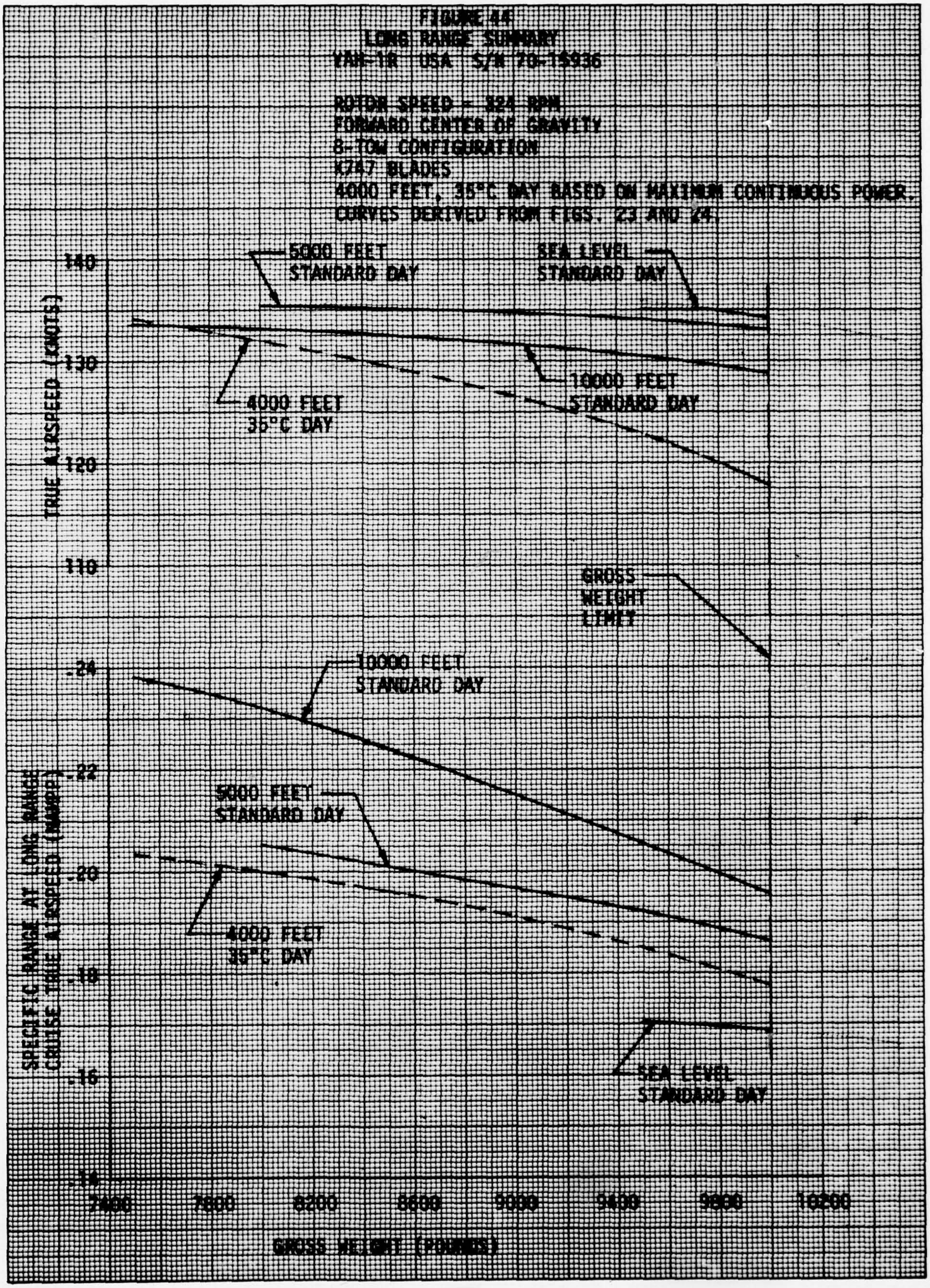


FIGURE 44
LONG RANGE SUMMARY
YAH-1R USA S/N 70-15936
ROTOR SPEED = 324 RPM
FORWARD CENTER OF GRAVITY
8-TOW CONFIGURATION
K747 BLADES
4000 FEET, 35°C DAY BASED ON MAXIMUM CONTINUOUS POWER.
CURVES DERIVED FROM FIGS. 23 AND 24.
5000 FEET
STANDARD DAY
SEA LEVEL
STANDARD DAY
10000 FEET
STANDARD DAY
4000 FEET
35°C DAY
GROSS
WEIGHT
LIMIT
10000 FEET
STANDARD DAY
5000 FEET
STANDARD DAY
4000 FEET
35°C DAY
SEA LEVEL
STANDARD DAY
TRUE AIRSPEED (KNOTS)
140
130
120
110
SPECIFIC RANGE AT LONG RANGE
CRUISE TRUE AIRSPEED (NAMPP)
.24
.22
.20
.18
.16
.14
7400
7800
8200
8600
9000
9400
9800
10200
GROSS WEIGHT (POUNDS)

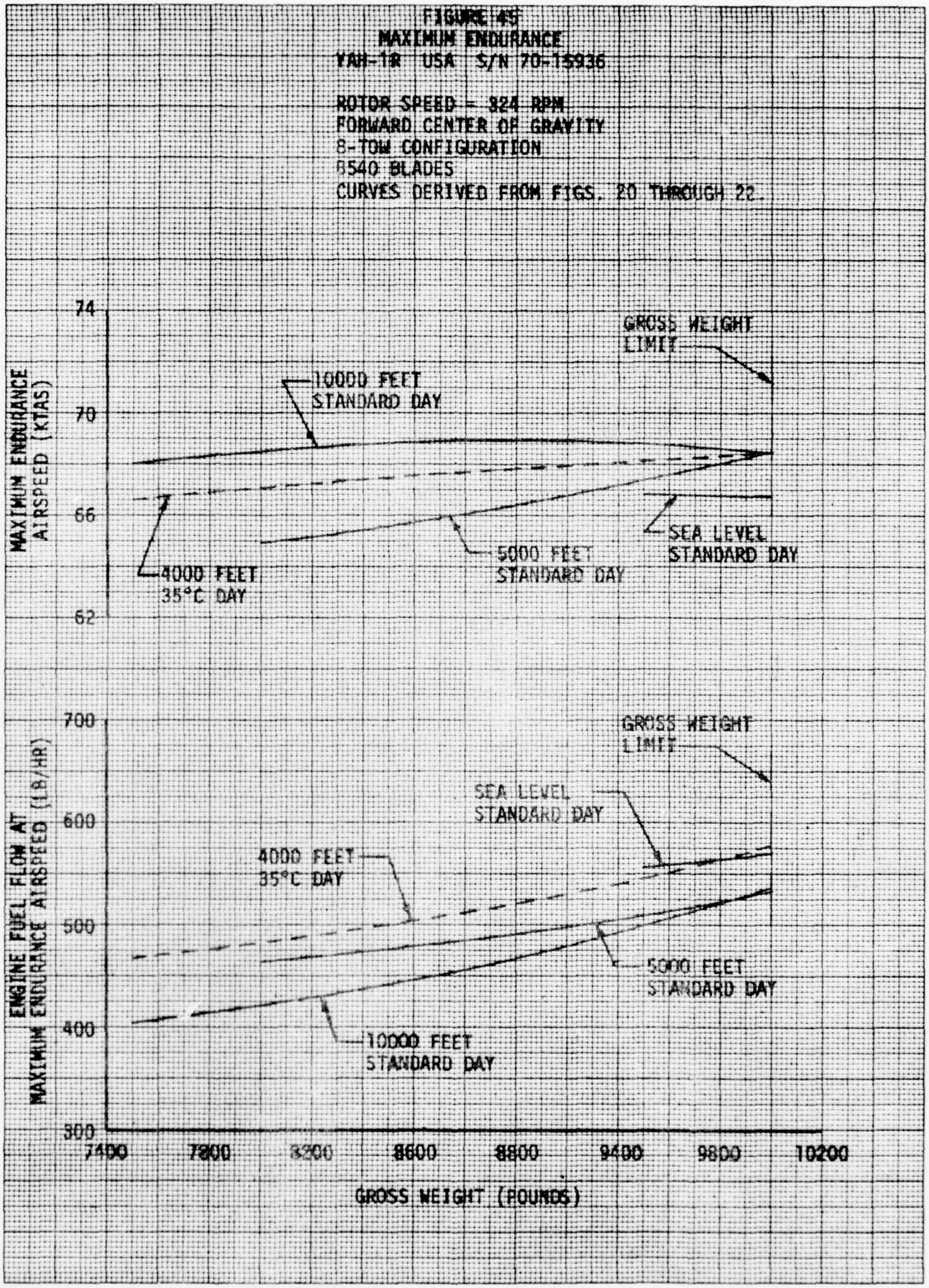


FIGURE 45
MAXIMUM ENDURANCE
YAH-1R USA S/N 70-15936
ROTOR SPEED = 324 RPM
FORWARD CENTER OF GRAVITY
8-TOW CONFIGURATION
B540 BLADES
CURVES DERIVED FROM FIGS. 20 THROUGH 22.
MAXIMUM ENDURANCE AIRSPEED (KTAS)
74
70
66
62
GROSS WEIGHT LIMIT
10000 FEET STANDARD DAY
SEA LEVEL STANDARD DAY
5000 FEET STANDARD DAY
4000 FEET 35°C DAY
ENGINE FUEL FLOW AT MAXIMUM ENDURANCE AIRSPEED (LB/HR)
700
600
500
400
300
GROSS WEIGHT LIMIT
SEA LEVEL STANDARD DAY
4000 FEET 35°C DAY
5000 FEET STANDARD DAY
10000 FEET STANDARD DAY
7400
7800
8200
8600
8800
9400
9800
10200
GROSS WEIGHT (POUNDS)

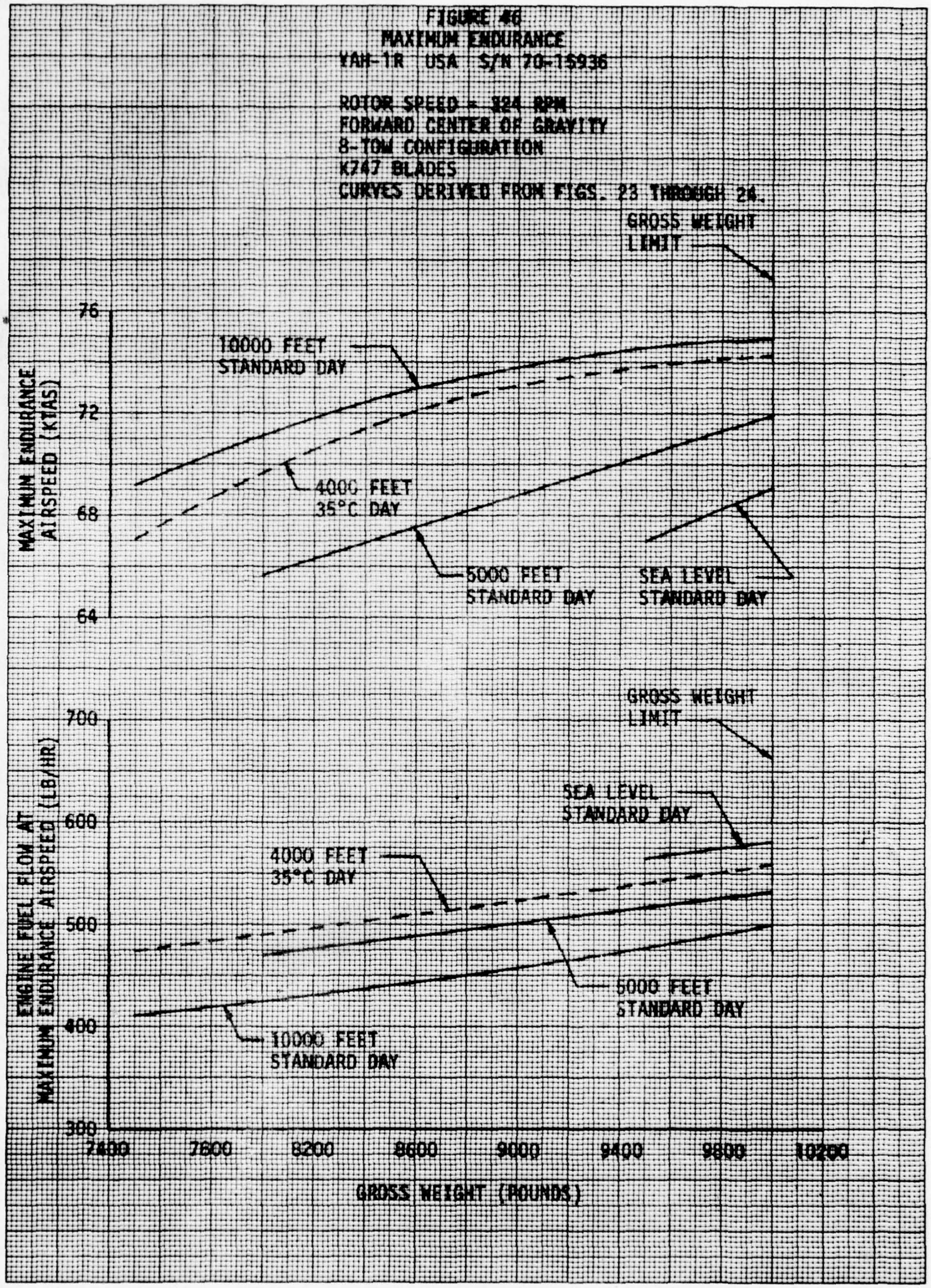
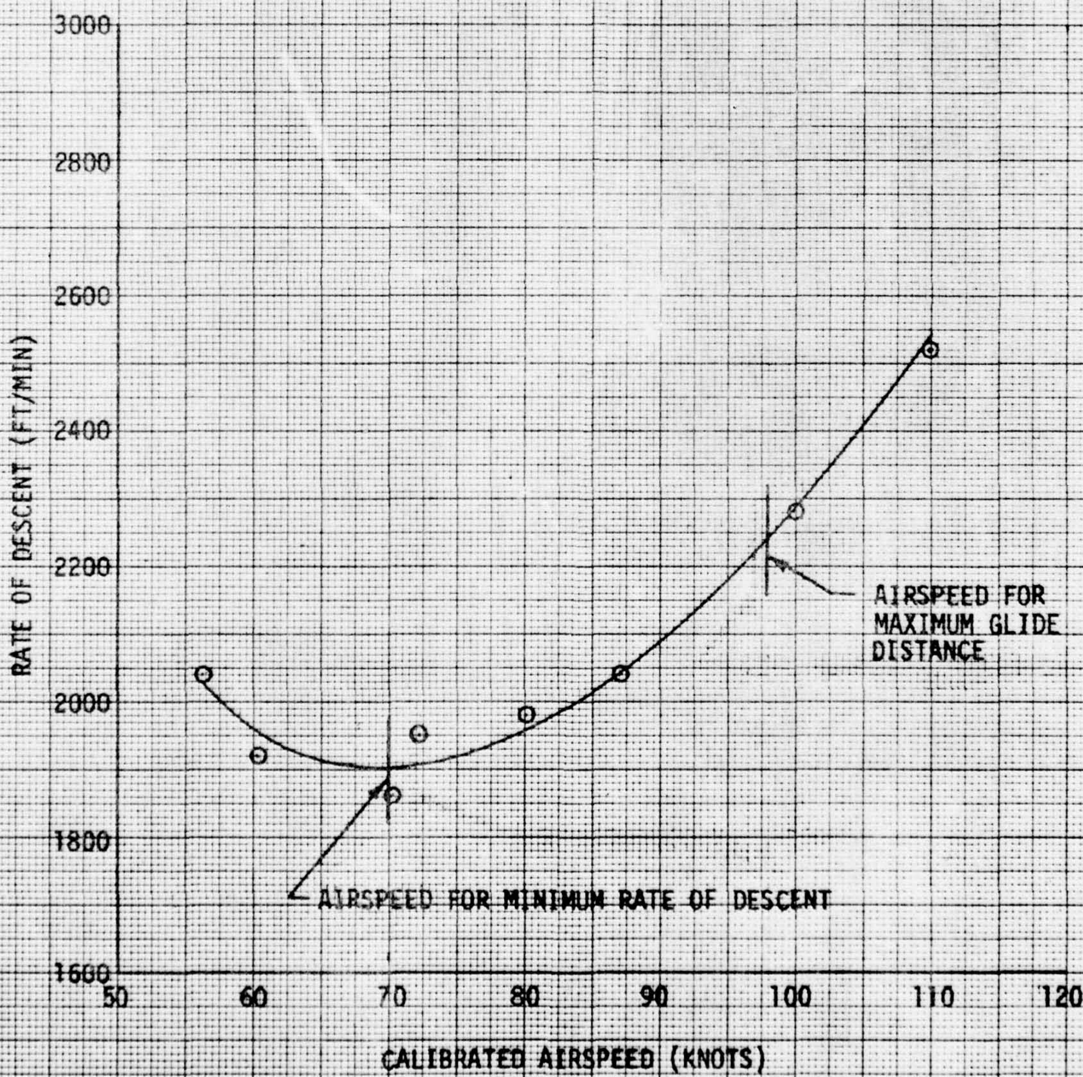


FIGURE 46
MAXIMUM ENDURANCE
YAH-1R USA S/N 70-15936
ROTOR SPEED = 324 RPM
FORWARD CENTER OF GRAVITY
8-TOW CONFIGURATION
K747 BLADES
CURVES DERIVED FROM FIGS. 23 THROUGH 24.
GROSS WEIGHT LIMIT
10000 FEET STANDARD DAY
4000 FEET 35°C DAY
5000 FEET STANDARD DAY
SEA LEVEL STANDARD DAY
MAXIMUM ENDURANCE AIRSPEED (KTAS)
76
72
68
64
GROSS WEIGHT LIMIT
SEA LEVEL STANDARD DAY
4000 FEET 35°C DAY
5000 FEET STANDARD DAY
10000 FEET STANDARD DAY
ENGINE FUEL FLOW AT MAXIMUM ENDURANCE AIRSPEED (LB/HR)
700
600
500
400
300
7400
7800
8200
8600
9000
9400
9800
10200
GROSS WEIGHT (POUNDS)

FIGURE 47
AUTOROTATIONAL DESCENT PERFORMANCE
YAH-1R USA S/N 70-15936

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	AVG C_T X10^4	CONFIGURATION
9100	196.0(MID)	0.1(RT)	5000	2.5	321	55.50	8-TOW

NOTES: 1. K747 BLADES S/N 1005 and 1009.
2. CURVE DERIVED FROM FIGS. 16, 23 AND 24.



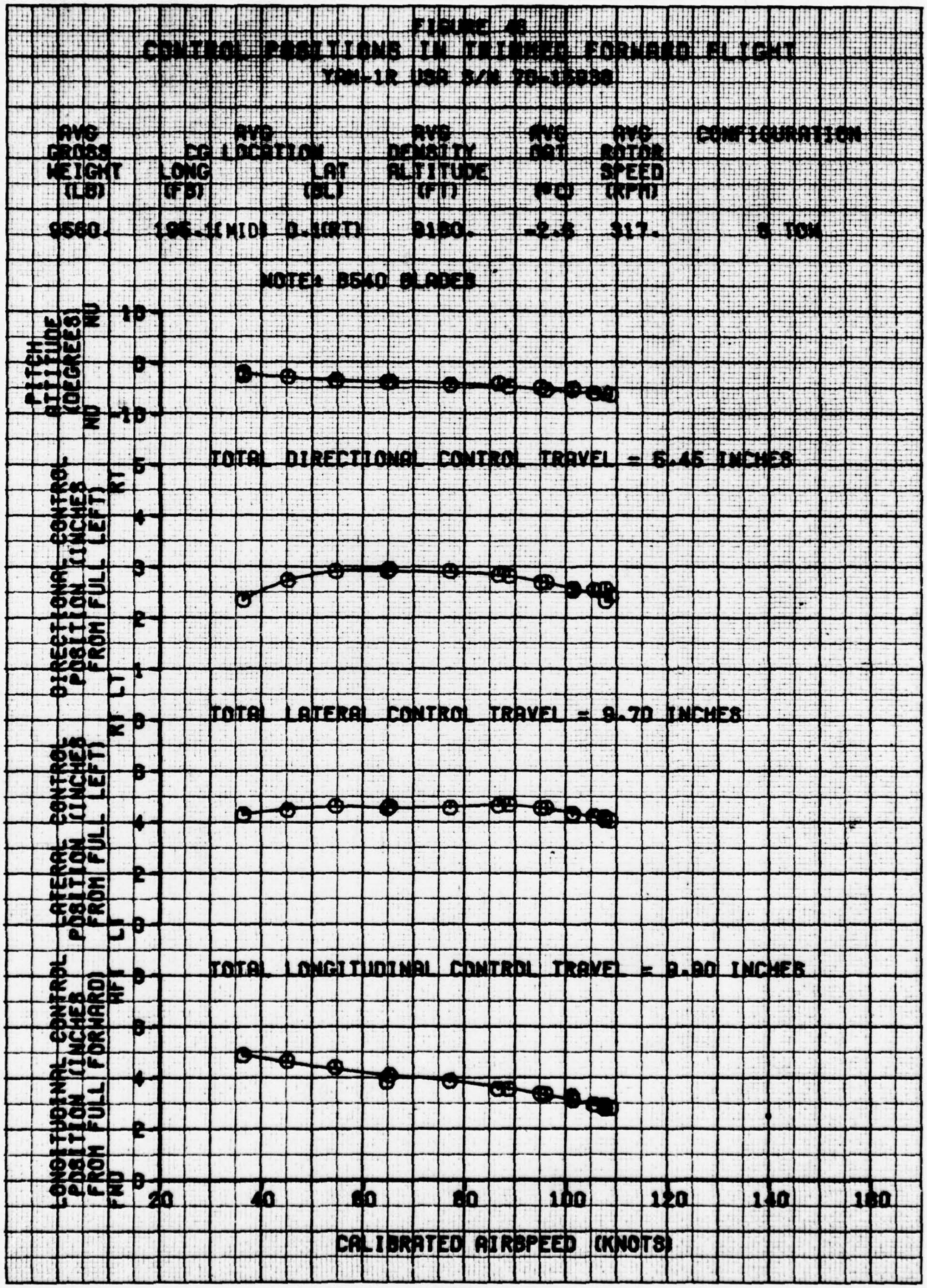

CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT
AVG GROSS WEIGHT (LB)
AVG CG LOCATION LONG (FS) LAT (BL)
AVG DENSITY ALTITUDE (FT)
AVG OAT (°C)
AVG ROTOR SPEED (RPM)
CONFIGURATION
NOTE: B540 BLADES
PITCH ATTITUDE (DEGREES) NU ND
TOTAL DIRECTIONAL CONTROL TRAVEL = 5.45 INCHES
DIRECTIONAL CONTROL POSITION (INCHES FROM FULL LEFT) RT LT
TOTAL LATERAL CONTROL TRAVEL = 9.70 INCHES
LATERAL CONTROL POSITION (INCHES FROM FULL LEFT) RT LT
TOTAL LONGITUDINAL CONTROL TRAVEL = 9.90 INCHES
LONGITUDINAL CONTROL POSITION (INCHES FROM FULL FORWARD) AFT FWD
CALIBRATED AIRSPEED (KNOTS)

FIGURE 49
CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT
YAH-1R USA S/N 70-15936

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	CONFIGURATION
9920	195.8(MID)	0.1(RT)	10640	0.5	319	8 TOW

NOTE: K747 BLADES

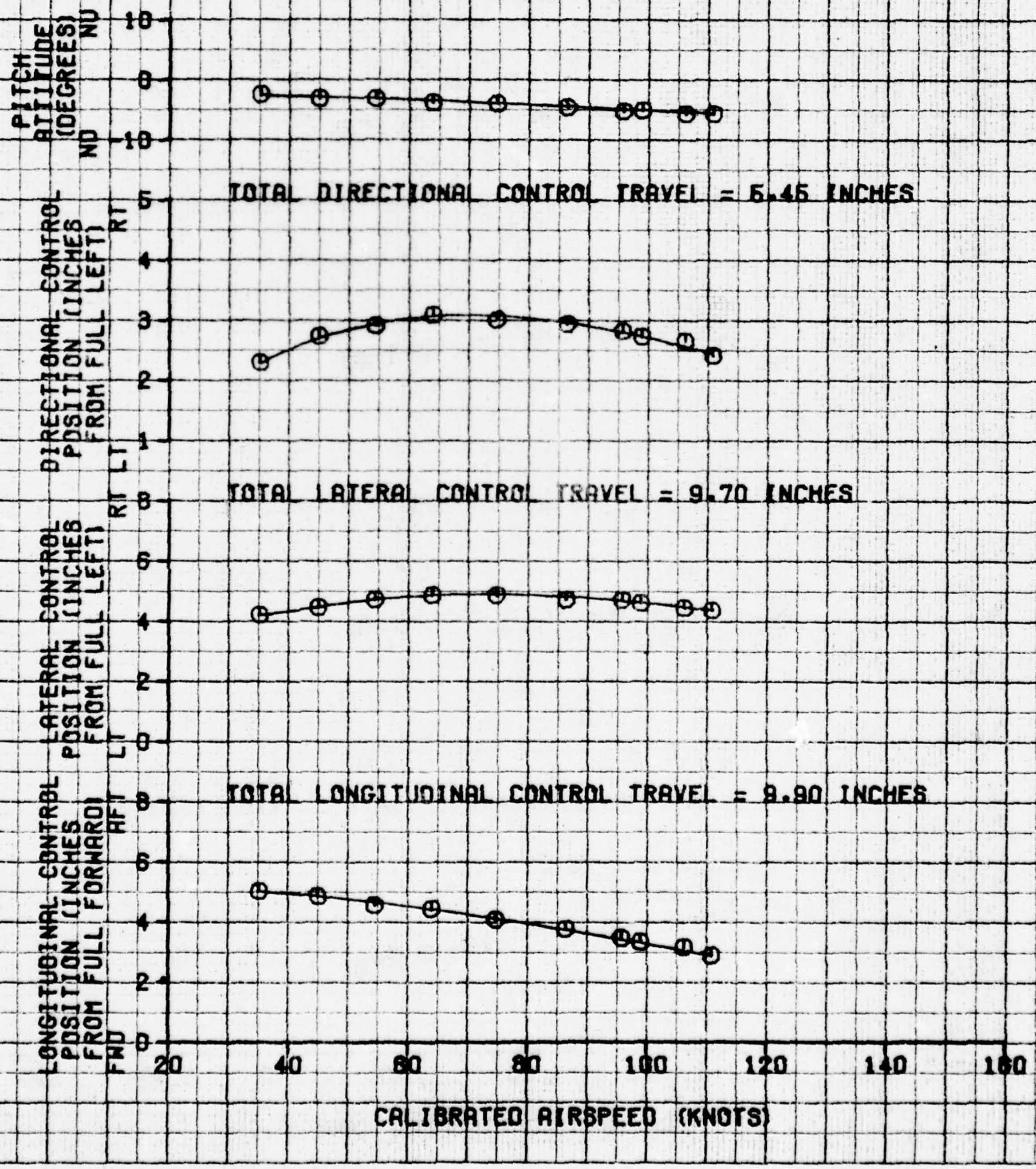
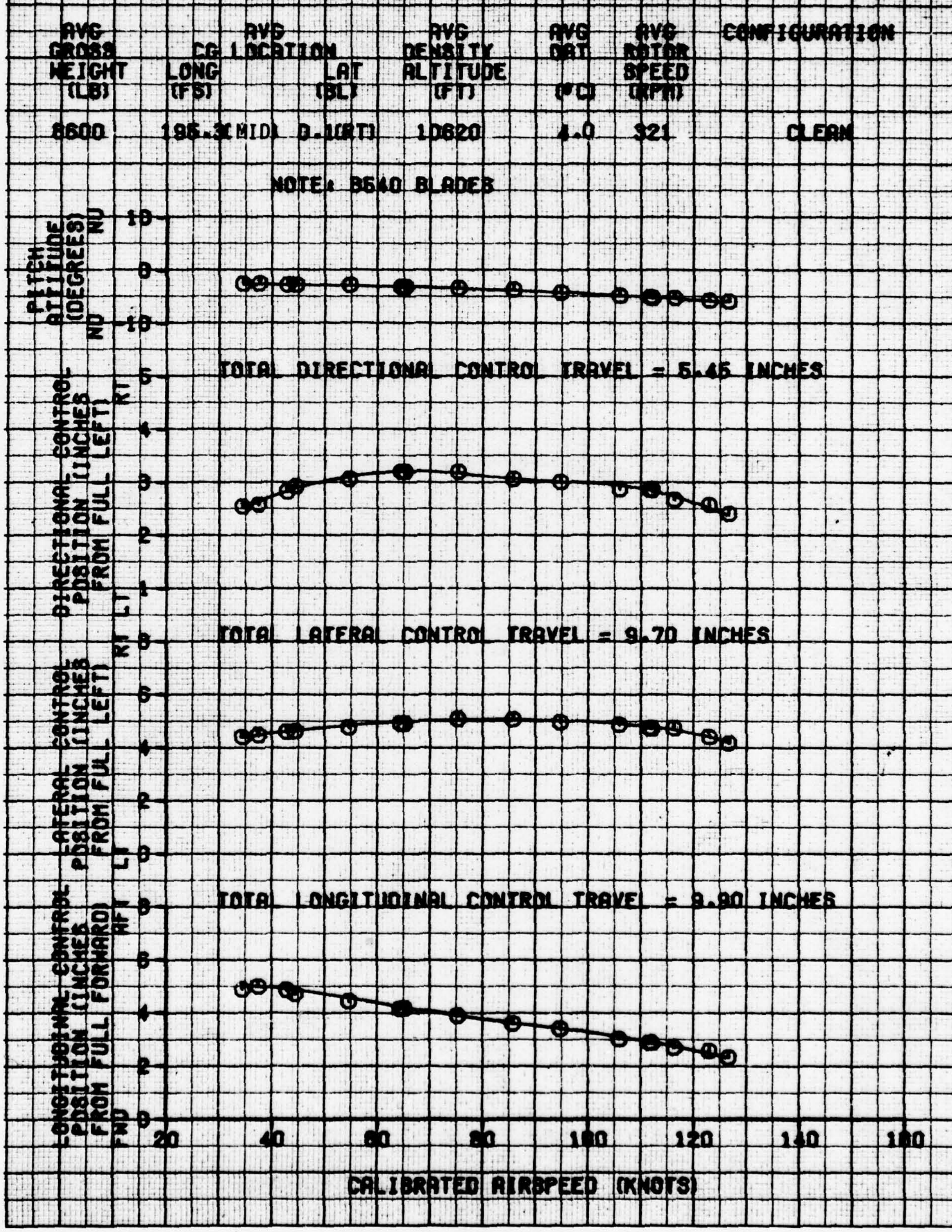


FIGURE 50
CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT
YAH-1R USA S/N 70-15936



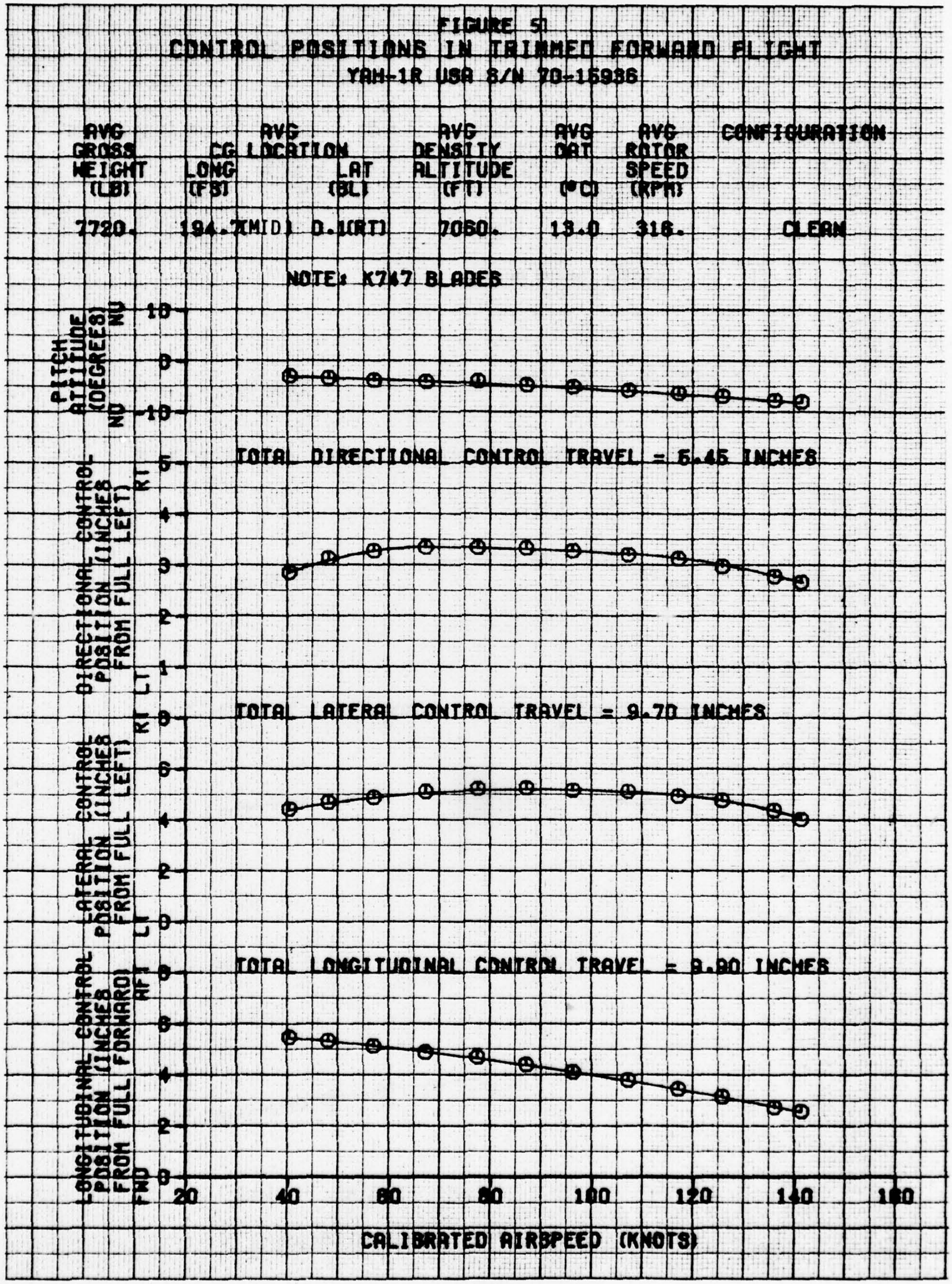


FIGURE 51
CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT
YAH-1R USA S/N 70-15936
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENSITY ALTITUDE (FT)
AVG OAT (°C)
AVG ROTOR SPEED (RPM)
CONFIGURATION
7720.
194.7(MID)
0.1(RT)
7060.
13.0
316.
CLEAN
NOTE: K747 BLADES
PITCH ATTITUDE (DEGREES)
NU
ND
TOTAL DIRECTIONAL CONTROL TRAVEL = 5.45 INCHES
DIRECTIONAL CONTROL POSITION (INCHES FROM FULL LEFT)
RT
LT
TOTAL LATERAL CONTROL TRAVEL = 9.70 INCHES
LATERAL CONTROL POSITION (INCHES FROM FULL LEFT)
RT
LT
TOTAL LONGITUDINAL CONTROL TRAVEL = 9.80 INCHES
LONGITUDINAL CONTROL POSITION (INCHES FROM FULL FORWARD)
AFT
FWD
CALIBRATED AIRSPEED (KNOTS)

FIGURE 52
MANEUVERING STABILITY
YAH-1R USA S/N 70-15936

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	AVG C_T X10^4	TRIM A/S (KCAS)	CONFIG	FLIGHT COND
○ (flagged)	9780	199.6(AFT)	0.1	6280	1.5	324	59.15	120	8TON	STEADY TURNS
○	9520	199.6(AFT)	0.1	6900	0.5	324	58.77	120	8TON	STEADY TURNS
□	9320	199.5(AFT)	0.1	6640	1.0	324	57.32	120	8TOW	PULLUPS
△	9200	199.5(AFT)	0.1	4340	3.5	324	52.76	120	8TOW	PUSHOVERS

NOTE: 1. K-747 BLADES S/N 1005 & 1009
2. FLAGGED SYMBOLS DENOTE LEFT TURN
3. SCAS ON

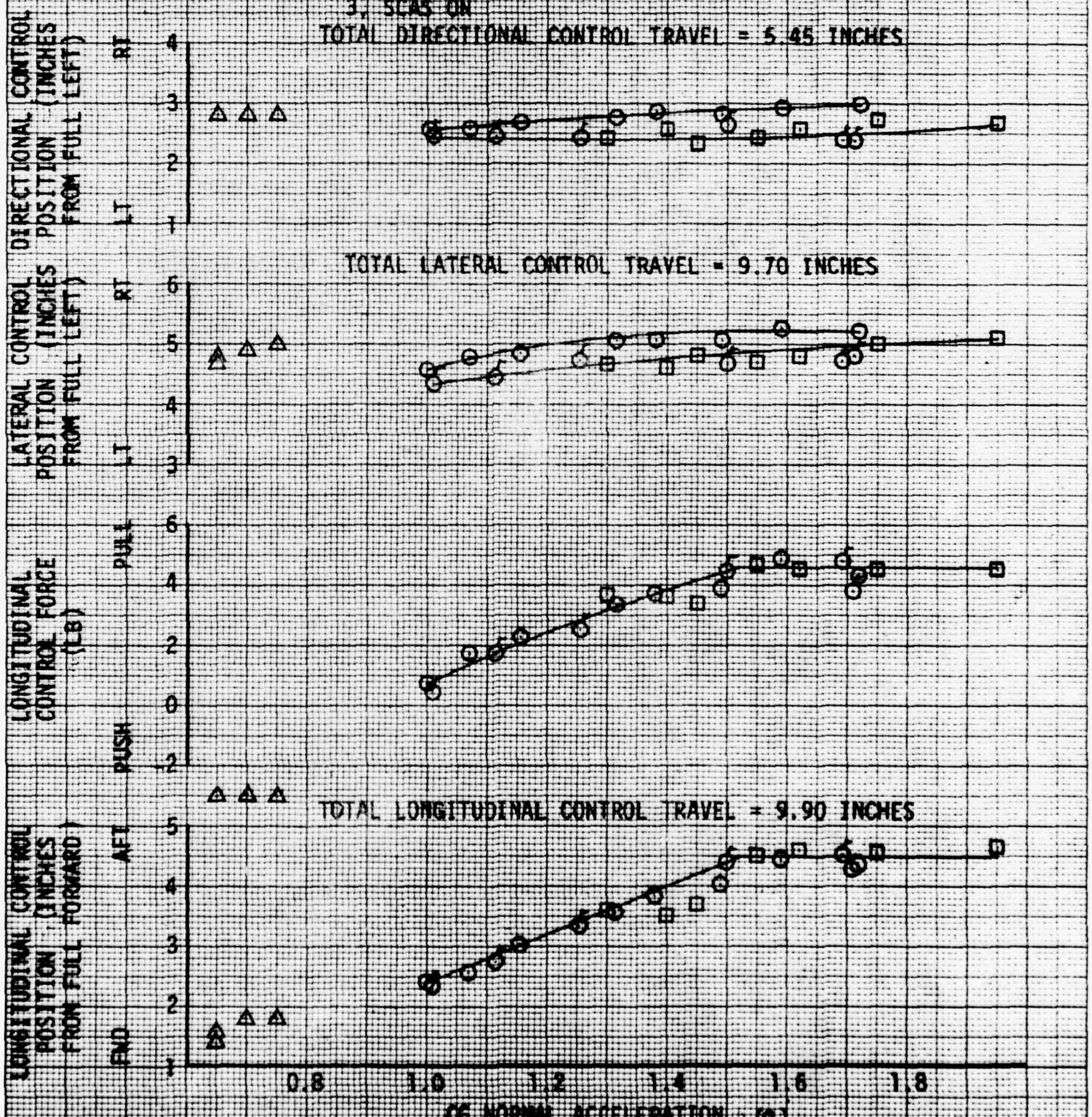


FIGURE 53

SIMULATED ENGINE FAILURE

YAH-1R USA S/N 70-15936

GROSS WEIGHT (LB)	CG LOCATION LONG (IN.)	CG LOCATION LAT (IN.)	DENSITY ALTITUDE (FT)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)	FLIGHT CONDITION
9780.	200.2 (AFT)	.1 (RT)	5580.	7.5	[illegible]18.	130.	LEVEL FLIGHT V_H

NOTE: K747 BLADES S/N 1005 AND 1009.

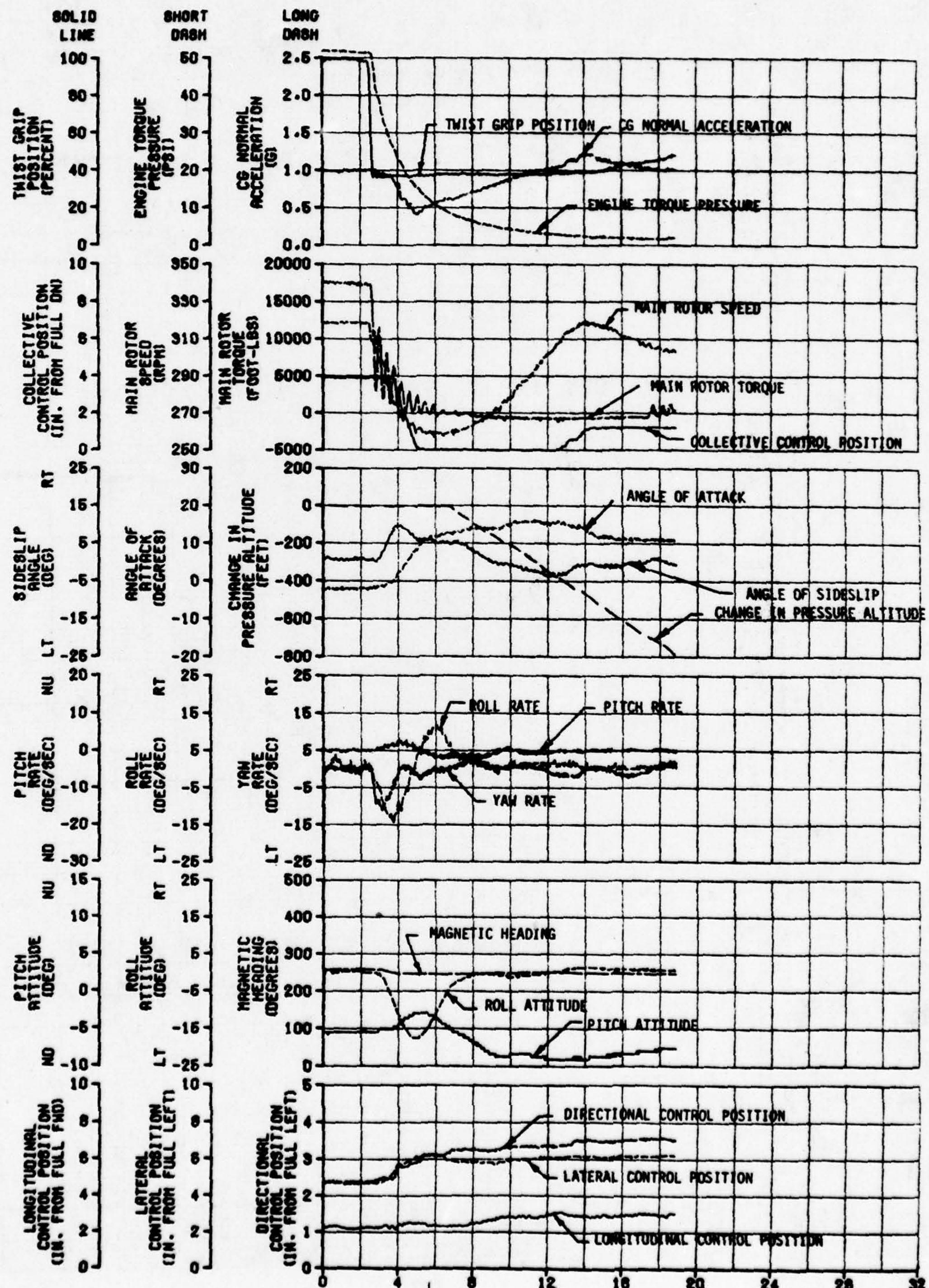


FIGURE 54
SIMULATED ENGINE FAILURE
YAH-1R USA S/N 70-15936

GROSS WEIGHT (LB)	CG LOCATION LONG (IN.)	CG LOCATION LAT (IN.)	DENSITY ALTITUDE (FT)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KT)	FLIGHT CONDITION
9880.	200.2 (AFT)	.1 (RT)	5300.	8.0	317.	73.	52 PSI TORQUE CLIMB

NOTE: K747 BLADES S/N 1005 AND 1009.

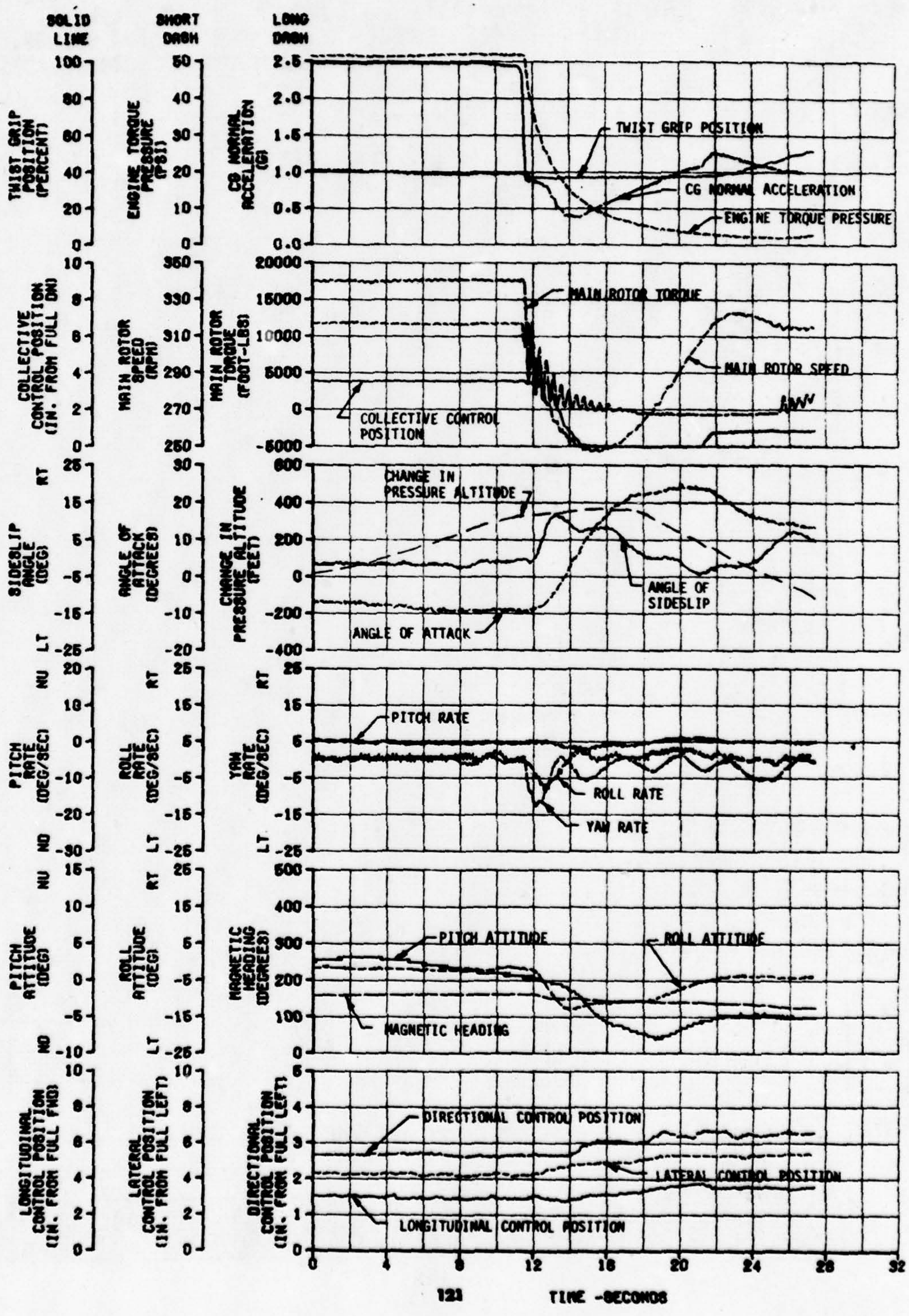


FIGURE 55
VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
PILOT SEAT LONGITUDINAL

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	AVG C_T	FLIGHT CONDITION	CONFIG
○	9560	195.2(MID)	0.1(RT)	8700	-2.0	319	65.23	LVL FLT	B-TOW
●	10040	195.4(MID)	0.1(RT)	8900	5.5	321	65.49	LVL FLT	B-TOW

NOTE: 1. OPEN SYMBOLS DENOTE B-540 ROTOR BLADES.
2. SHADED SYMBOLS DENOTE K-747 ROTOR BLADES.

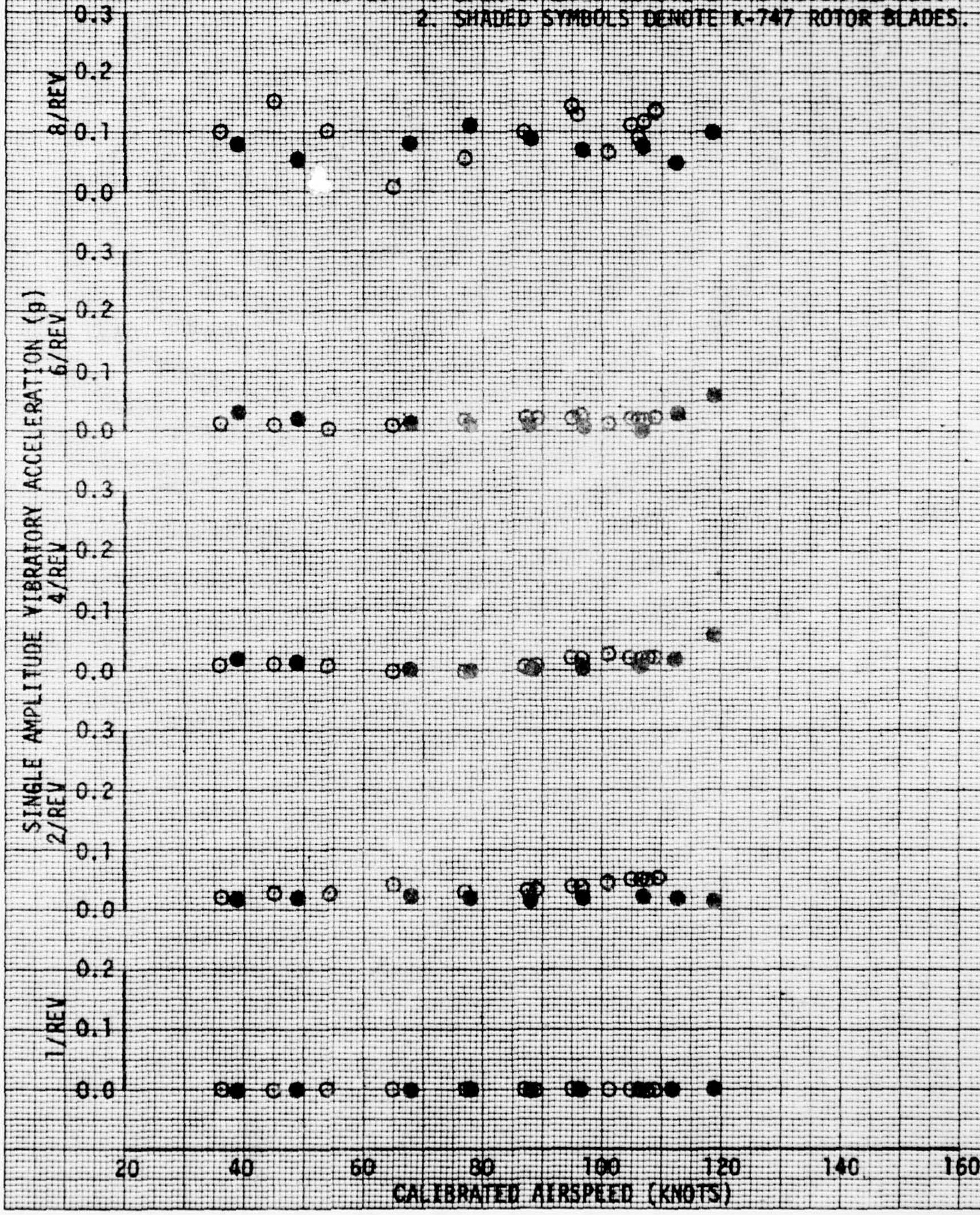
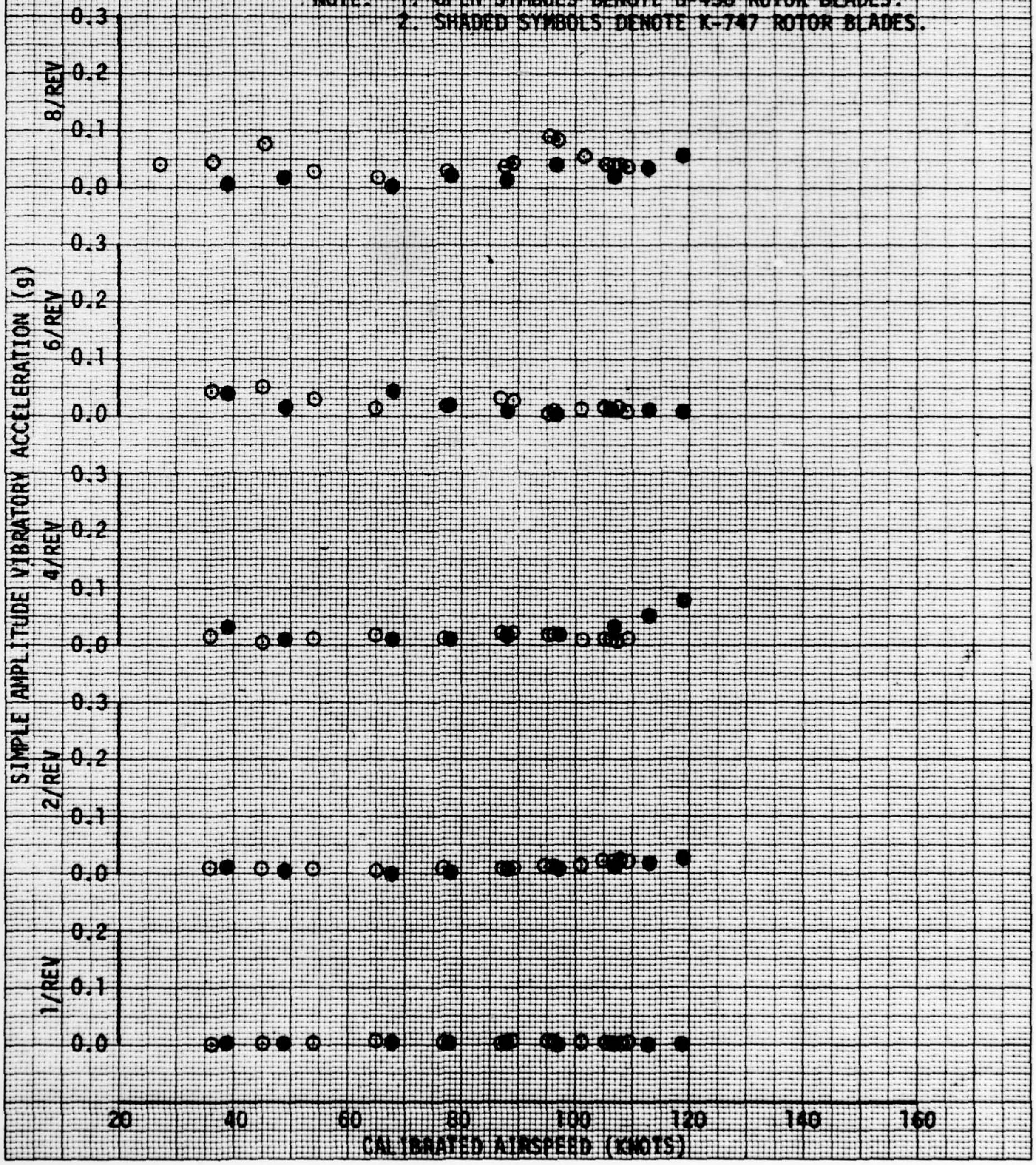


FIGURE 56
VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
PILOT SEAT LATERAL

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	AVG C_T	FLIGHT CONDITION	CONFIG
○	9560	195.2(MID)	0.1(RT)	8700	-2.0	319	65.23	LVL FLT	B-TOW
●	10040	195.4(MID)	0.1(RT)	8900	5.5	321	65.49	LVL FLT	B-TOW

NOTE: 1. OPEN SYMBOLS DENOTE B-450 ROTOR BLADES.
2. SHADED SYMBOLS DENOTE K-747 ROTOR BLADES.



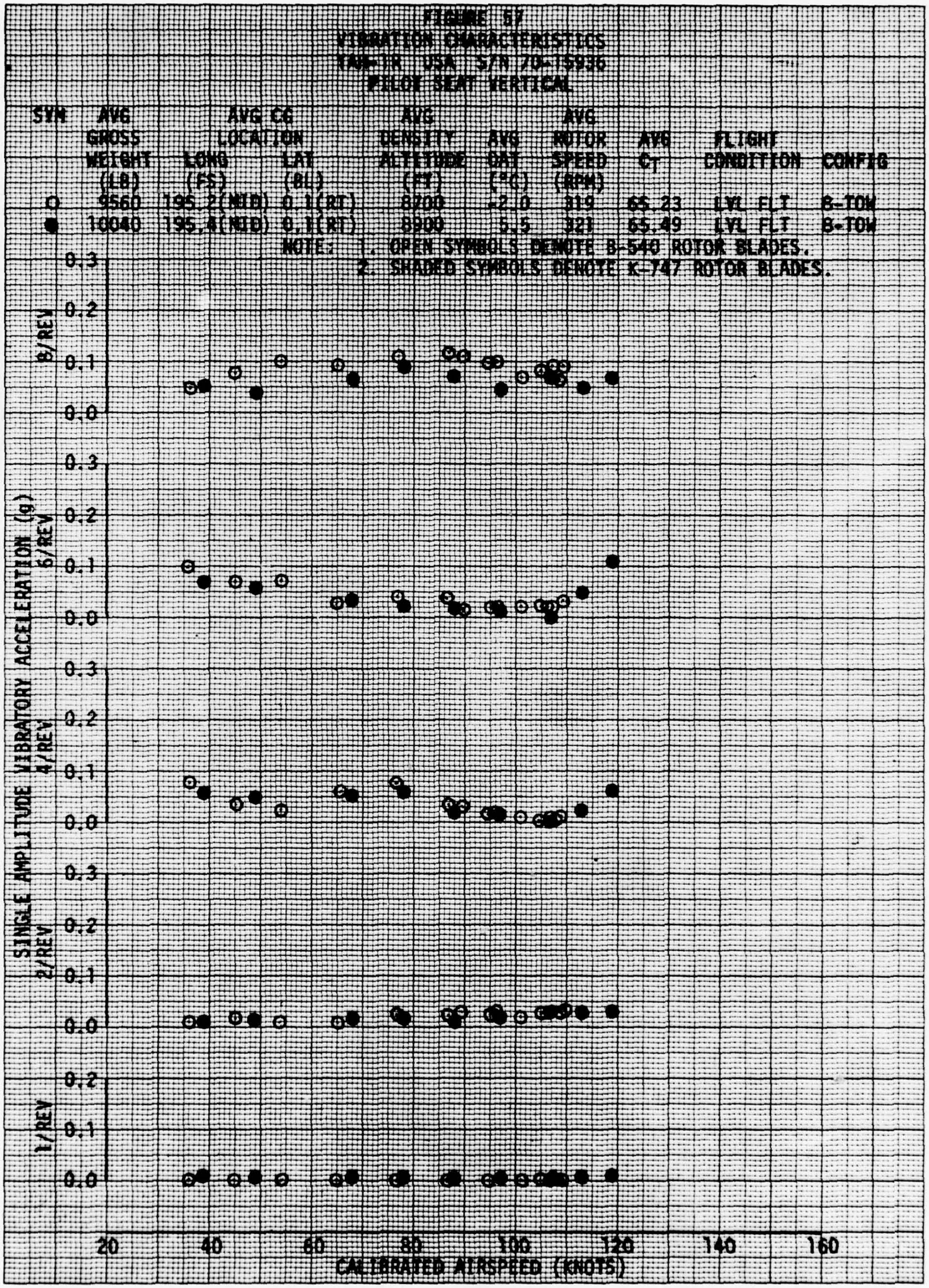


FIGURE 57
VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
PILOT SEAT VERTICAL

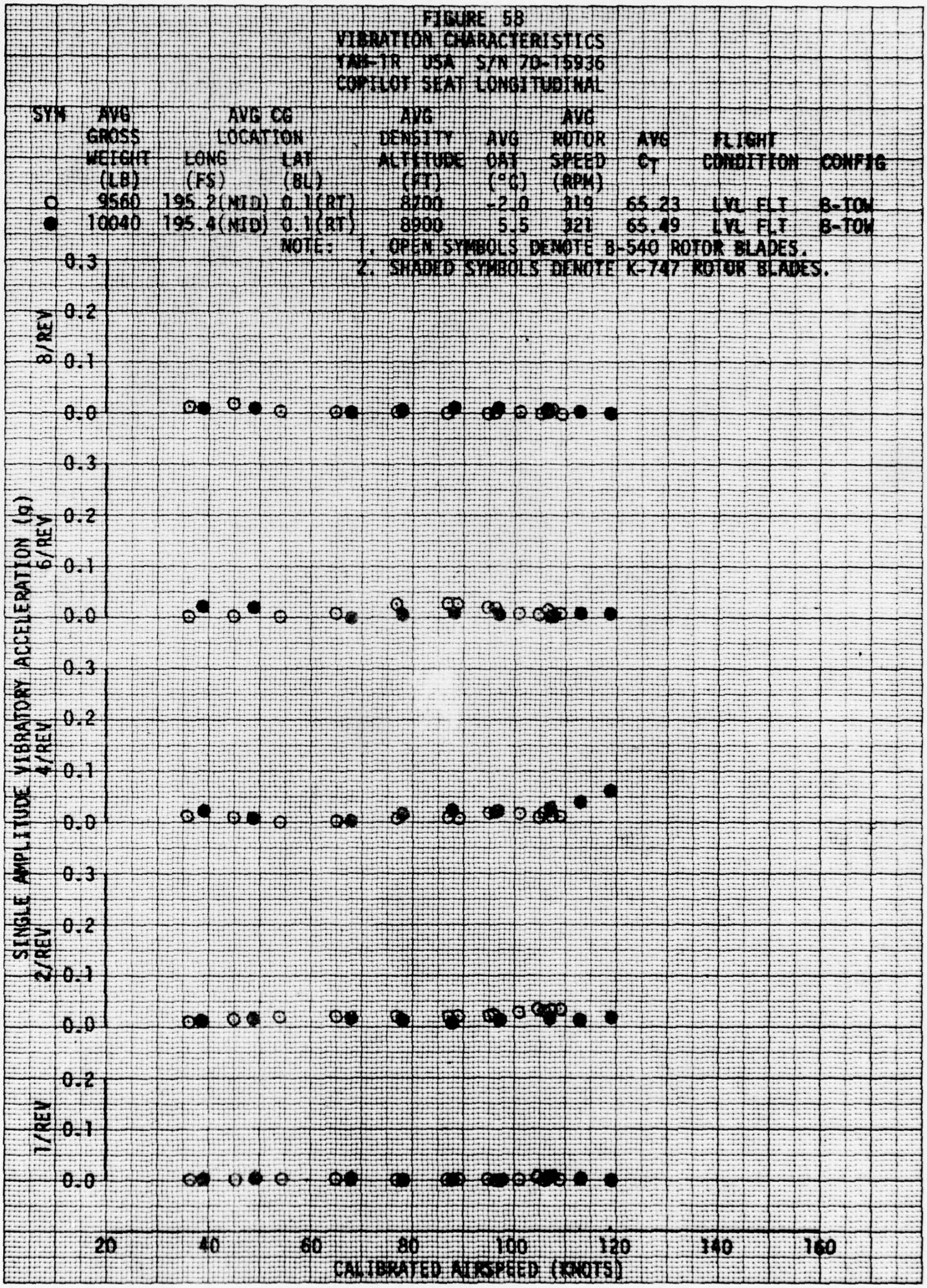
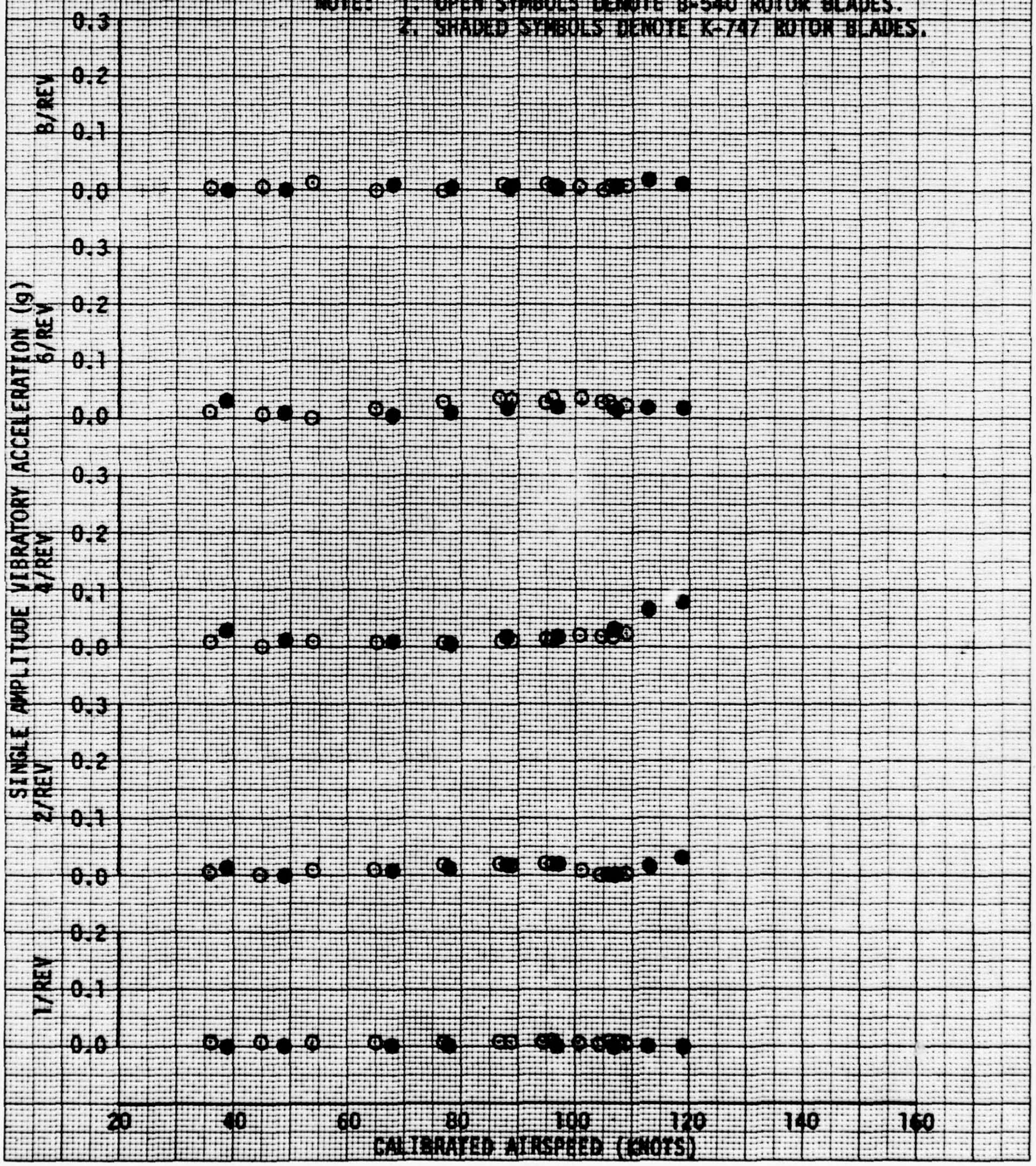


FIGURE 58
VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
COPILOT SEAT LONGITUDINAL
SYM
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENSITY ALTITUDE (FT)
AVG OAT (°C)
AVG ROTOR SPEED (RPM)
AVG C_T
FLIGHT CONDITION
CONFIG
○ 9560 195.2(MID) 0.1(RT) 8200 -2.0 319 65.23 LVL FLT B-TOW
● 10040 195.4(MID) 0.1(RT) 8900 5.5 321 65.49 LVL FLT B-TOW
NOTE: 1. OPEN SYMBOLS DENOTE B-540 ROTOR BLADES.
2. SHADED SYMBOLS DENOTE K-747 ROTOR BLADES.
SINGLE AMPLITUDE VIBRATORY ACCELERATION (g)
8/REV
6/REV
4/REV
2/REV
1/REV
0.3
0.2
0.1
0.0
20
40
60
80
100
120
140
160
CALIBRATED AIRSPEED (KNOTS)

FIGURE 59
VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
COPILOT SEAT LATERAL

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	AVG C_T	FLIGHT CONDITION	CONFIG
○	9560	195.2(MID)	0.1(RT)	8200	-2.0	319	65.23	LVL FLT	8-TOW
●	10040	195.4(MID)	0.1(RT)	8900	5.5	321	65.49	LVL FLT	8-TOW

NOTE: 1. OPEN SYMBOLS DENOTE B-540 ROTOR BLADES.
2. SHADED SYMBOLS DENOTE K-747 ROTOR BLADES.



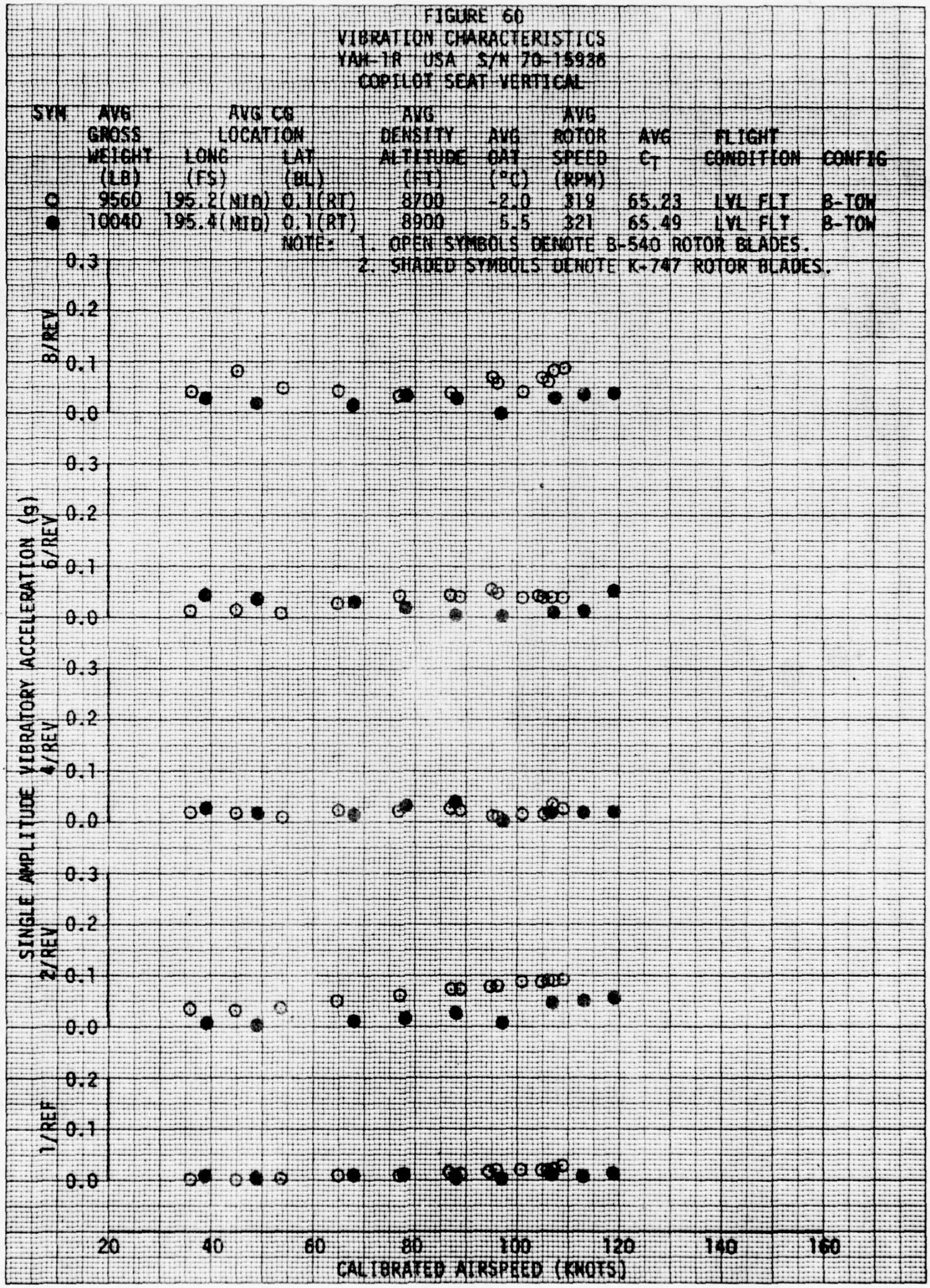


FIGURE 60
VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
COPILOT SEAT VERTICAL
SYM | AVG GROSS WEIGHT (LB) | AVG CG LOCATION LONG (FS) | LAT (BL) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG ROTOR SPEED (RPM) | AVG C_T | FLIGHT CONDITION | CONFIG
○ 9560 195.2(MID) 0.1(RT) 8700 -2.0 319 65.23 LVL FLT 8-TOW
● 10040 195.4(MID) 0.1(RT) 8900 5.5 321 65.49 LVL FLT 8-TOW
NOTE: 1. OPEN SYMBOLS DENOTE B-540 ROTOR BLADES.
2. SHADED SYMBOLS DENOTE K-747 ROTOR BLADES.
SINGLE AMPLITUDE VIBRATORY ACCELERATION (g)
8/REV
6/REV
4/REV
2/REV
1/REF
0.0
0.1
0.2
0.3
20
40
60
80
100
120
140
160
CALIBRATED AIRSPEED (KNOTS)

FIGURE 61
VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
PILOT INSTRUMENT PANEL LONGITUDINAL

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	AVG C_T	FLIGHT CONDITION	CONFIG
○	9560	195.2(MID)	0.1(RT)	8700	-2.0	319	65.23	LVL FLT	B-TOW
●	10040	195.4(MID)	0.1(RT)	8900	5.5	321	65.49	LVL FLT	B-TOW

NOTE: 1. OPEN SYMBOLS DENOTE B-540 ROTOR BLADES.
2. SHADED SYMBOLS DENOTE K-747 ROTOR BLADES.

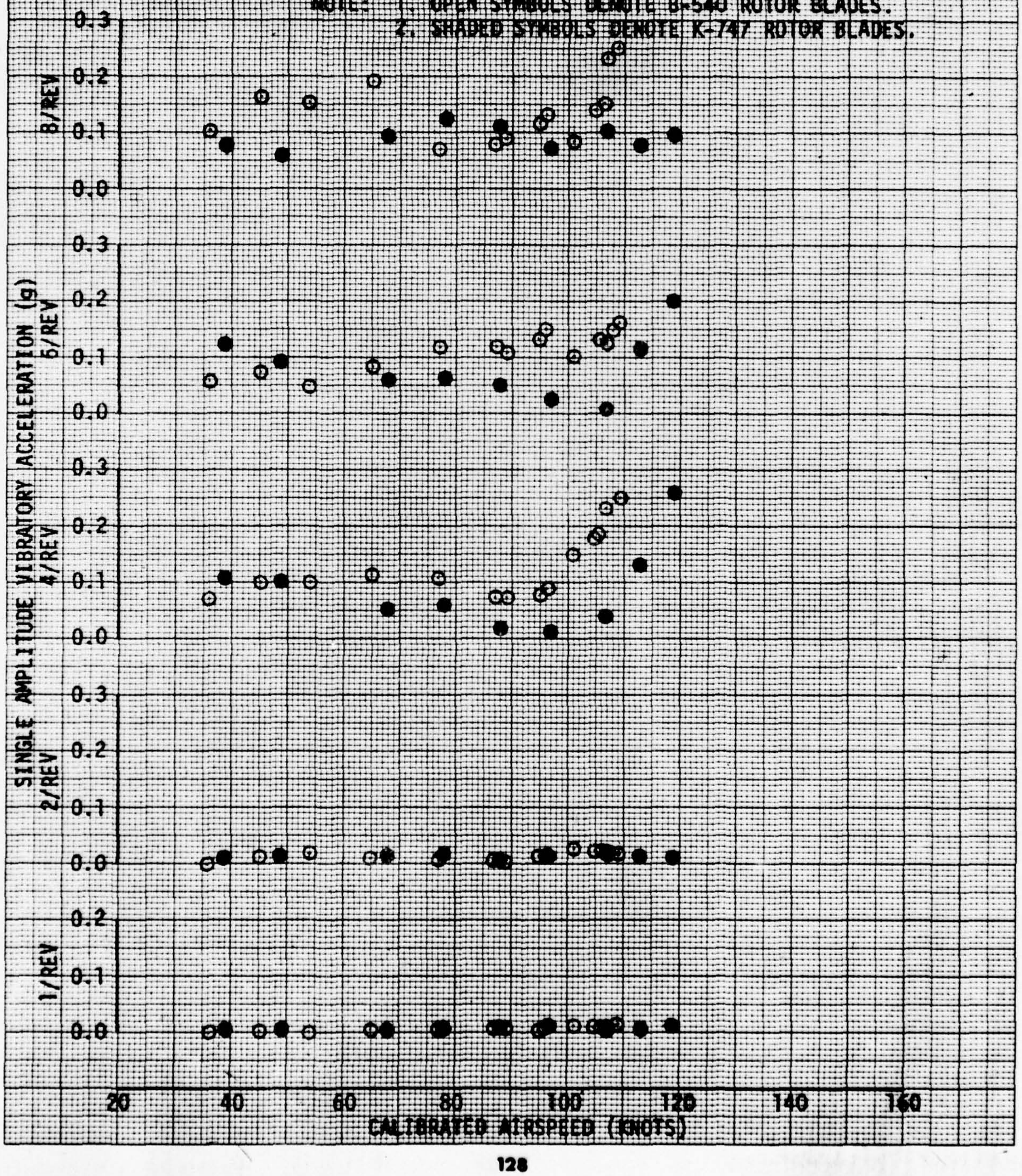


FIGURE 62
VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
PILOT INSTRUMENT PANEL LATERAL

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	AVG C_T	FLIGHT CONDITION	CONFIG
○	9560	195.2(MID)	0.1(RT)	8700	-2.0	319	65.23	LVL FLT	B-TOW
●	10040	195.4(MID)	0.1(RT)	8900	5.5	321	65.49	LVL FLT	B-TOW

NOTE: 1. OPEN SYMBOLS DENOTE B-540 ROTOR BLADES.
2. SHADED SYMBOLS DENOTE K-747 ROTOR BLADES.

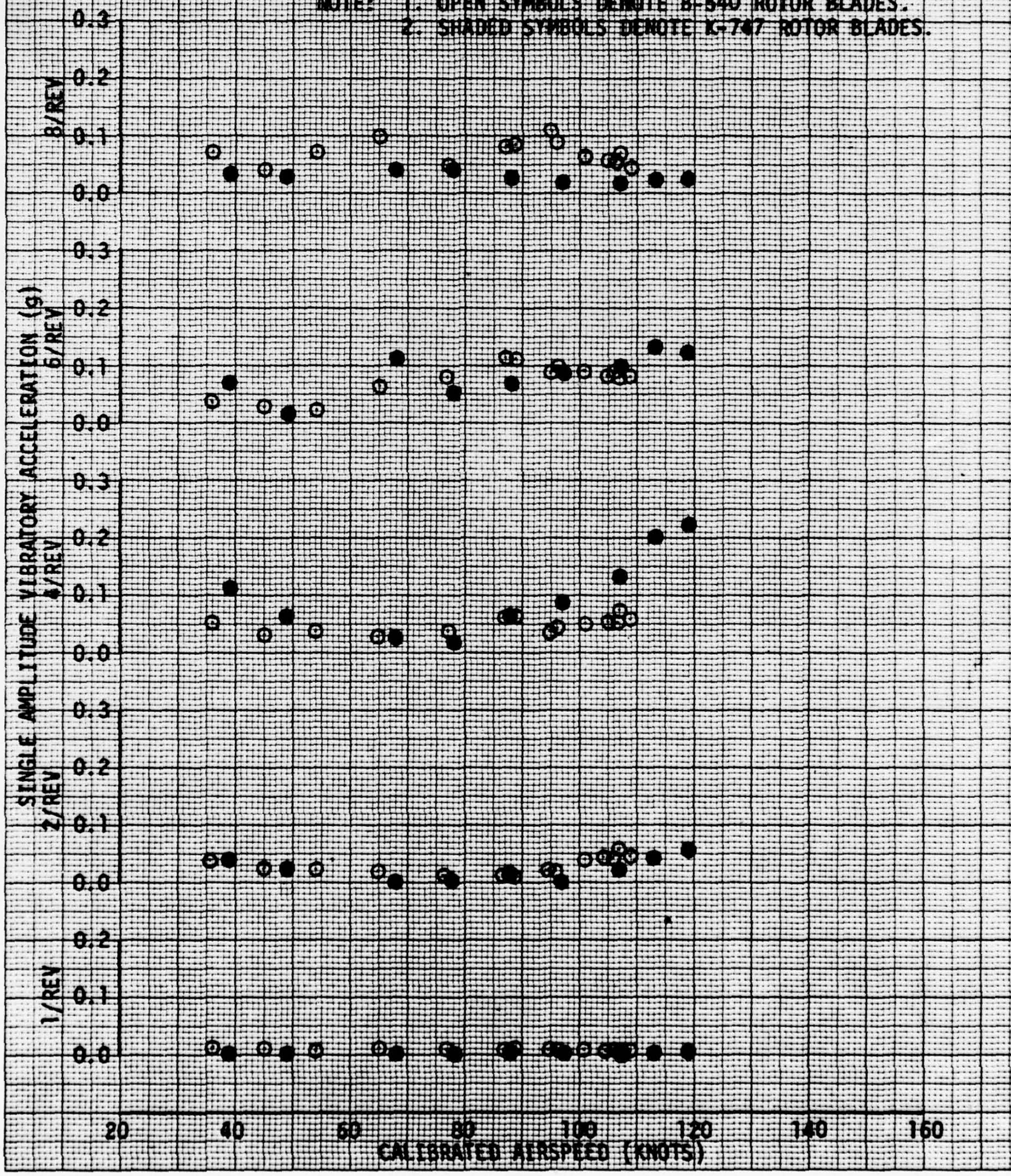
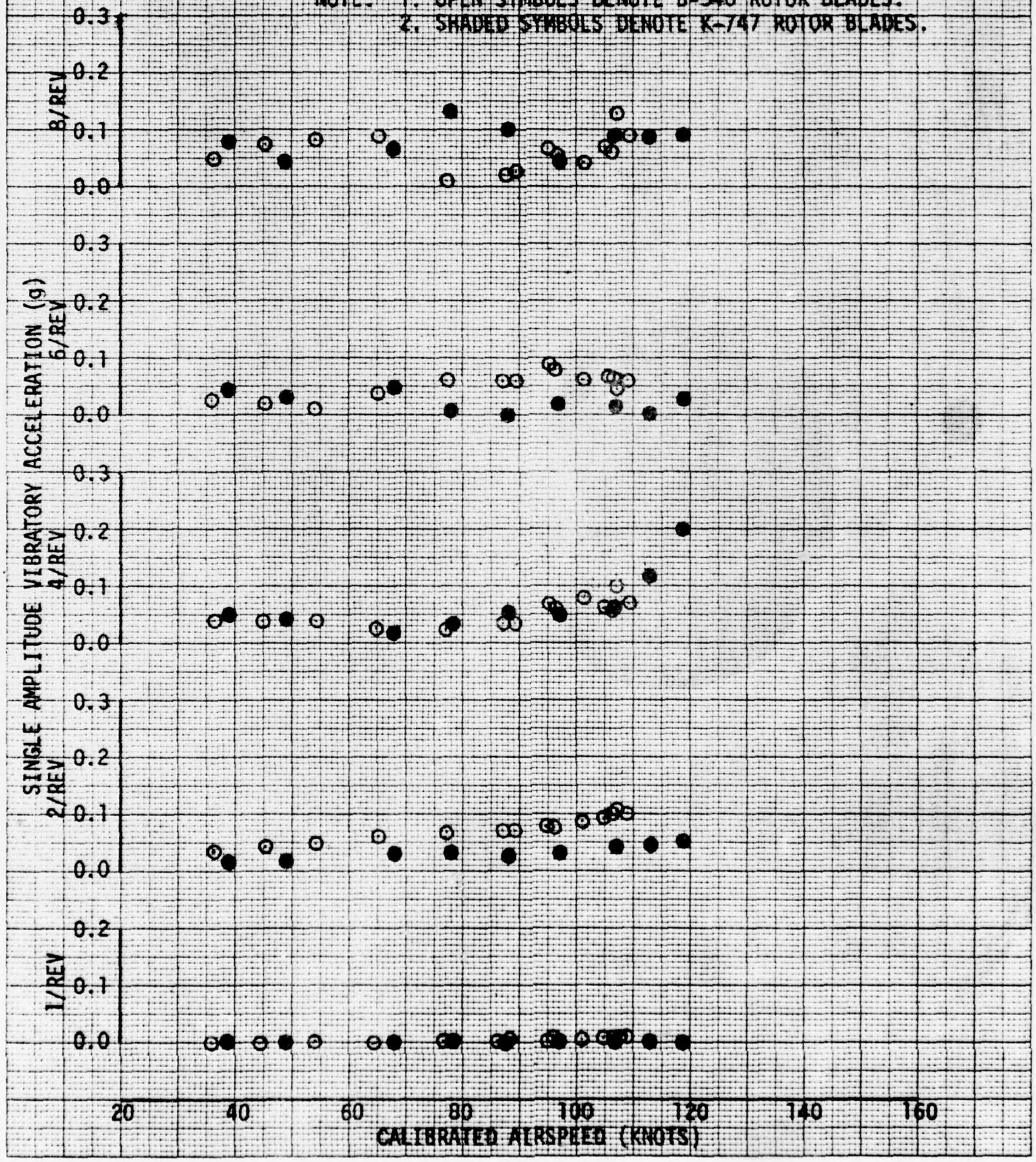


FIGURE 63
VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
PILOT INSTRUMENT PANEL VERTICAL

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	AVG C_T	FLIGHT CONDITION	CONFIG
○	9560	195.2(MID)	0.1(RT)	8700	-2.0	319	65.23	LVL FLT	8-TOW
●	10040	195.4(MID)	0.1(RT)	8900	5.5	321	65.49	LVL FLT	8-TOW

NOTE: 1. OPEN SYMBOLS DENOTE B-540 ROTOR BLADES.
2. SHADED SYMBOLS DENOTE K-747 ROTOR BLADES.



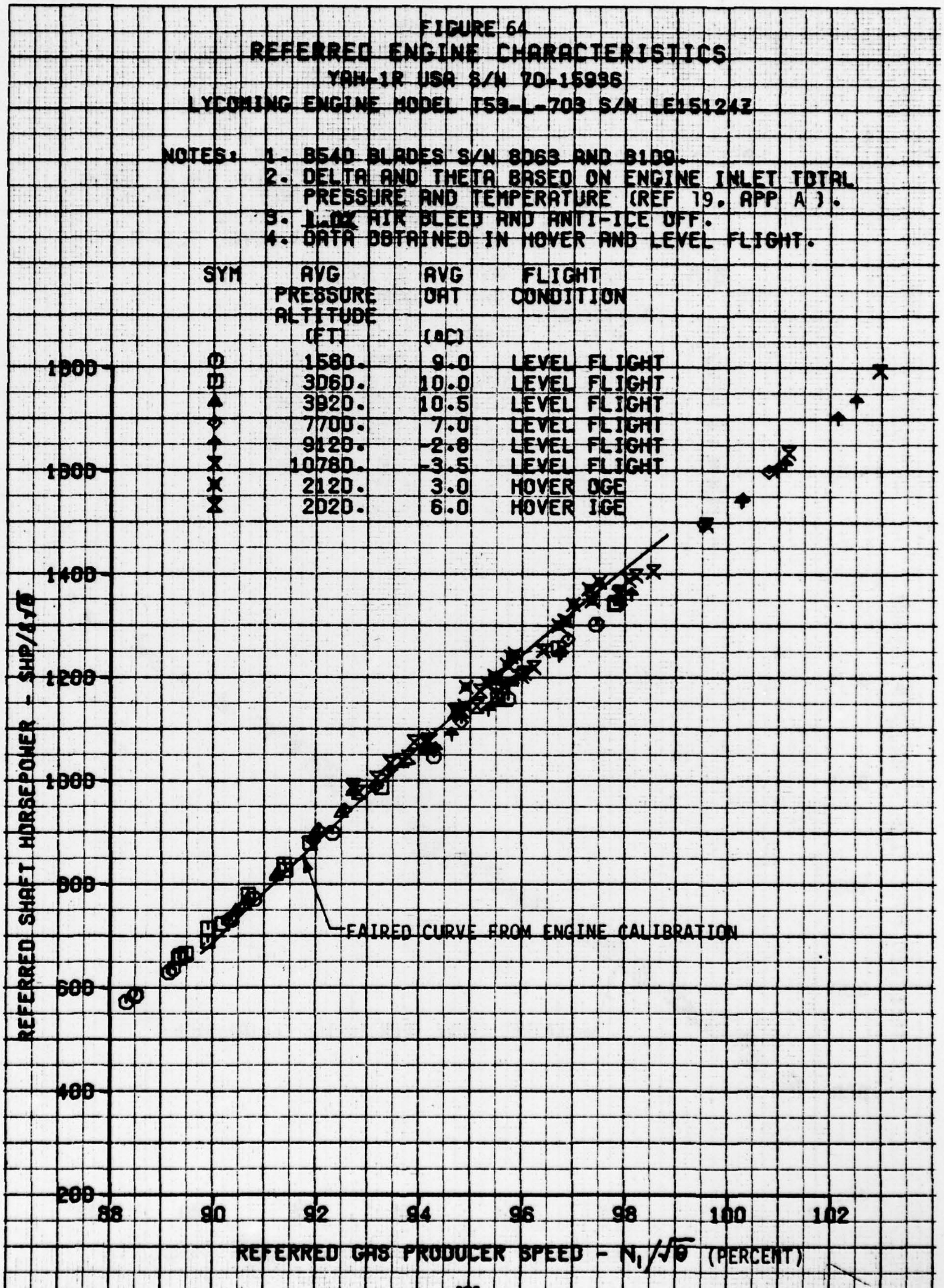
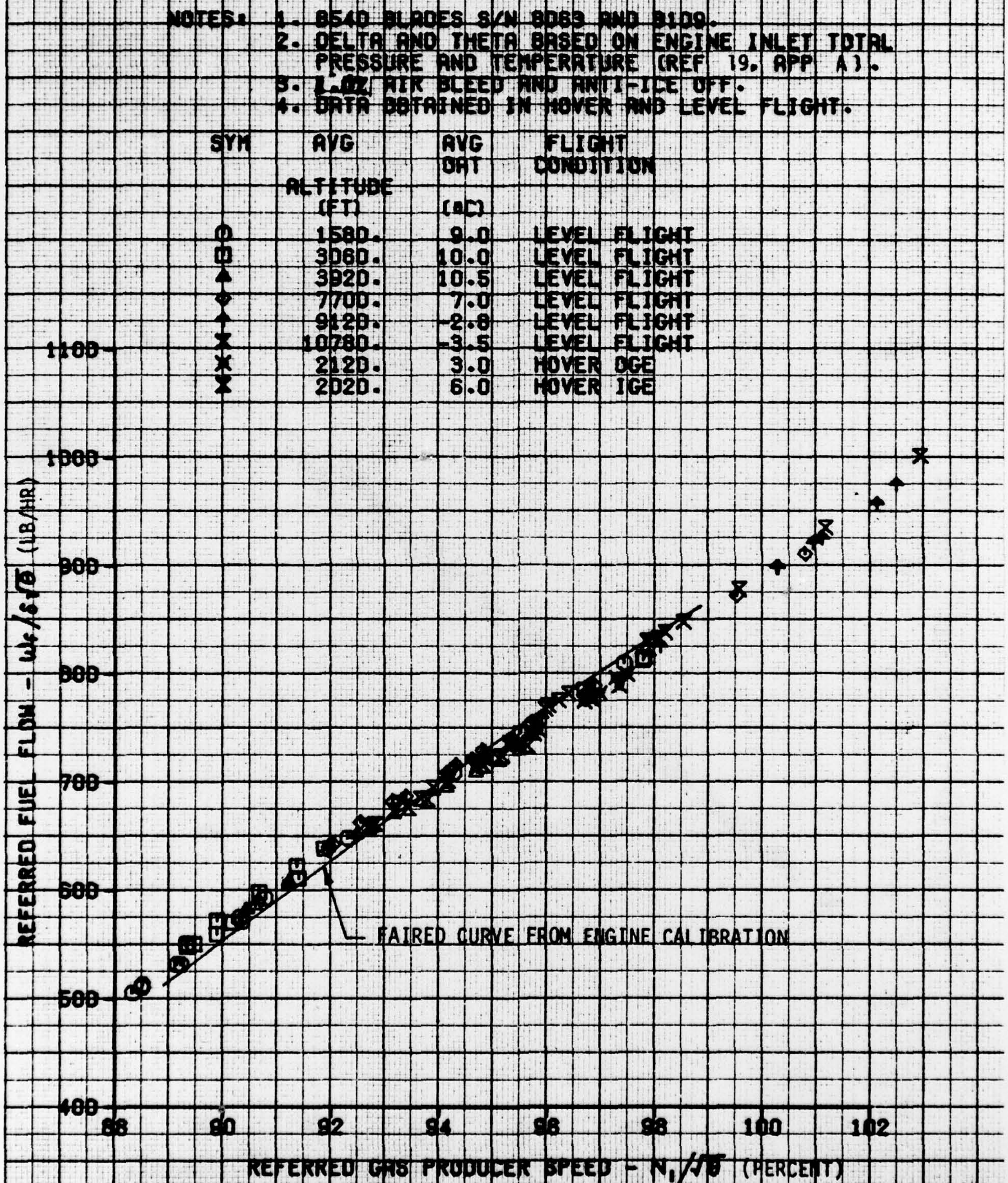


FIGURE 64
REFERRED ENGINE CHARACTERISTICS
YAH-1R USA S/N 70-15936
LYCOMING ENGINE MODEL T53-L-703 S/N LE15124Z

FIGURE 65
REFERRED ENGINE CHARACTERISTICS
YAH-1R USA S/N 70-15936
LYCOMING ENGINE MODEL T53-L-703 S/N LE15124Z



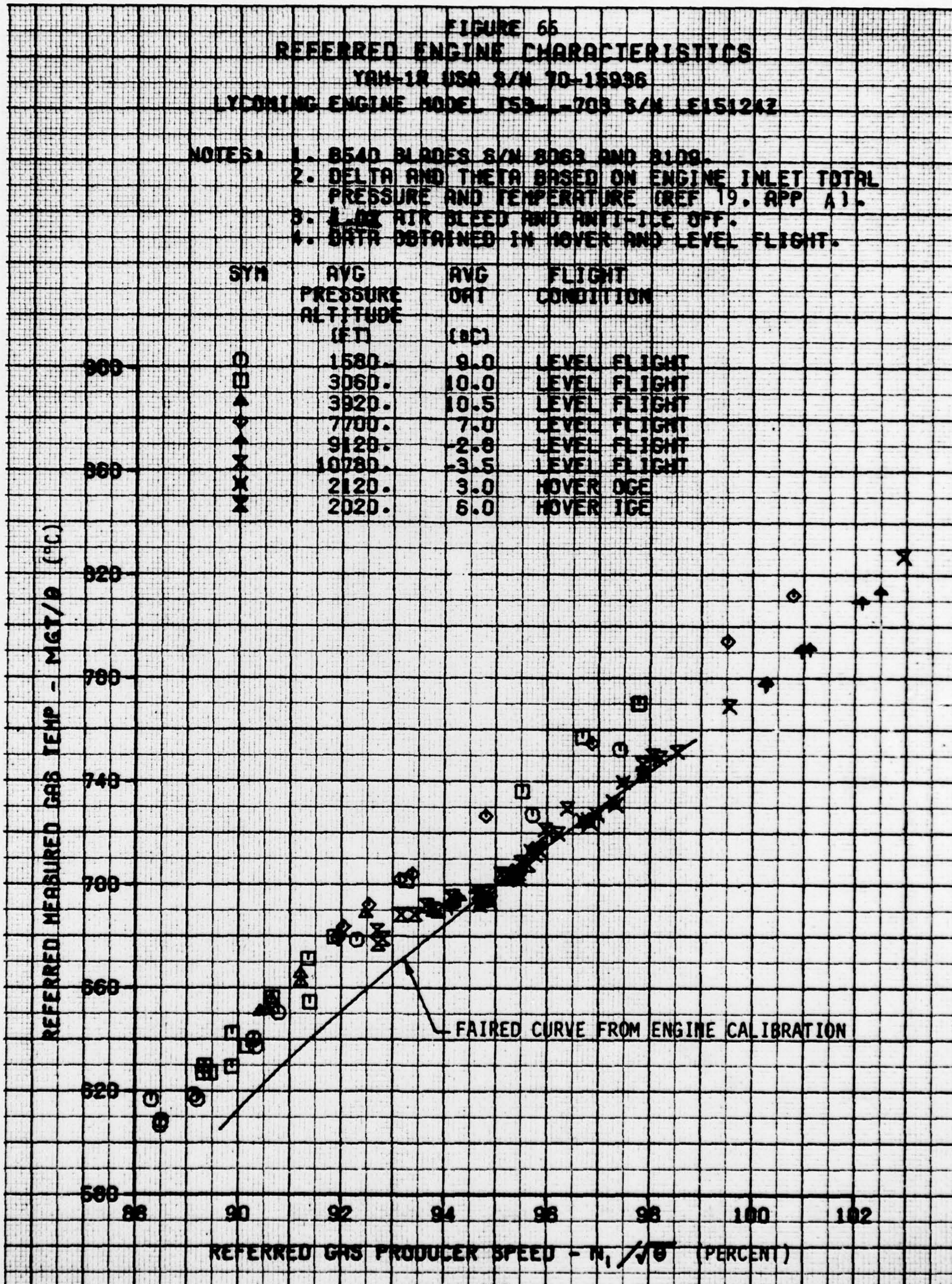


FIGURE 66
REFERRED ENGINE CHARACTERISTICS
YAH-1R USA S/N 70-15936
LYCOMING ENGINE MODEL T53-L-703 S/N LE151247
NOTES: 1. B540 BLADES S/N 8068 AND 8109.
2. DELTA AND THETA BASED ON ENGINE INLET TOTAL PRESSURE AND TEMPERATURE (REF 19, APP A).
3. 4.0% AIR BLEED AND ANTI-ICE OFF.
4. DATA OBTAINED IN HOVER AND LEVEL FLIGHT.
SYM | AVG PRESSURE ALTITUDE (FT) | AVG OAT (°C) | FLIGHT CONDITION
1580. | 9.0 | LEVEL FLIGHT
3060. | 10.0 | LEVEL FLIGHT
3920. | 10.5 | LEVEL FLIGHT
7700. | 7.0 | LEVEL FLIGHT
9120. | -2.8 | LEVEL FLIGHT
10780. | -3.5 | LEVEL FLIGHT
2120. | 3.0 | HOVER OGE
2020. | 6.0 | HOVER IGE
FAIRED CURVE FROM ENGINE CALIBRATION
REFERRED MEASURED GAS TEMP - MGT/θ (°C)
900
860
820
780
740
700
660
620
580
88
90
92
94
96
98
100
102
REFERRED GAS PRODUCER SPEED - $N_1/\sqrt{\theta}$ (PERCENT)

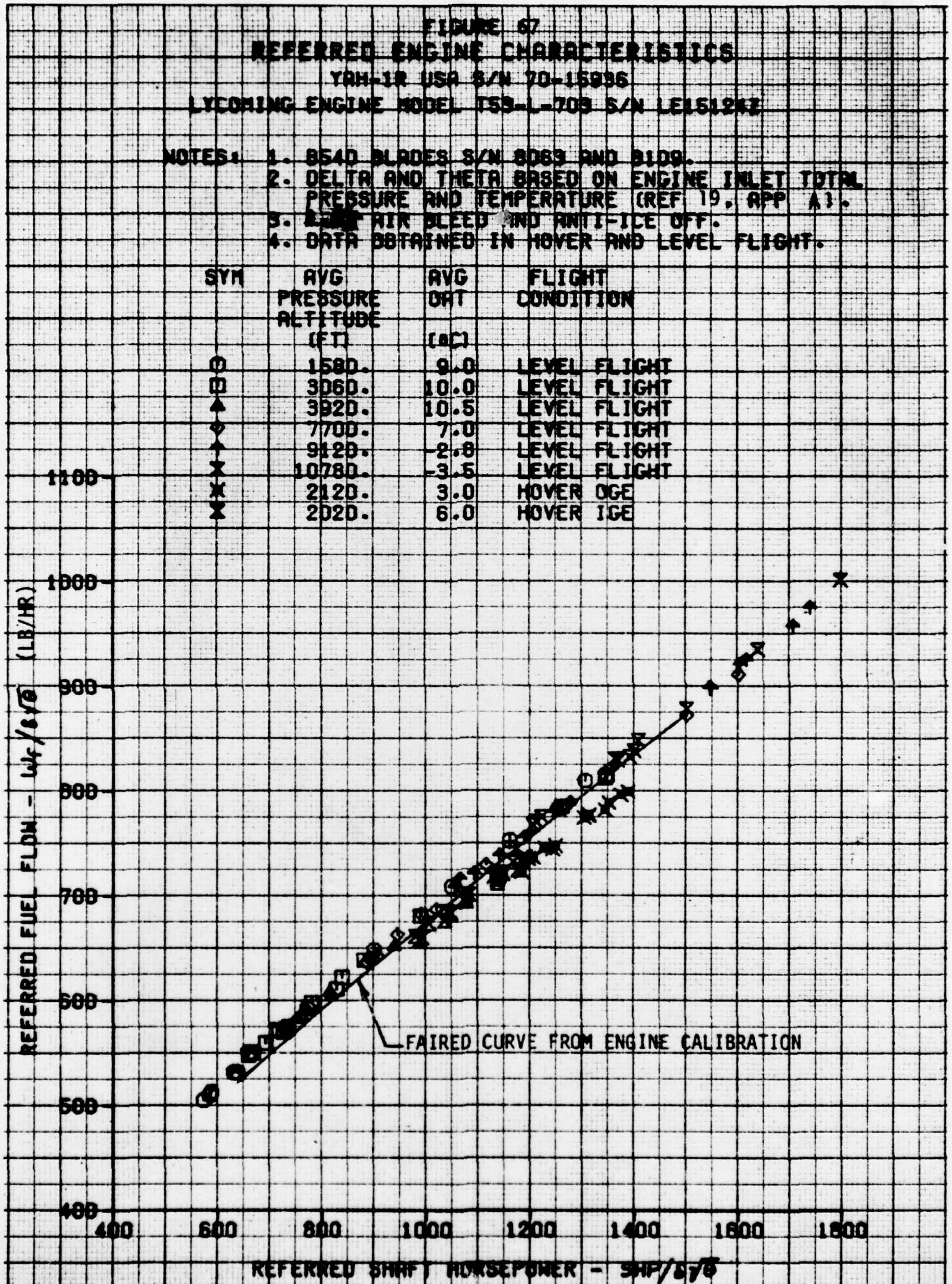


FIGURE 67
REFERRED ENGINE CHARACTERISTICS
YAH-1R USA S/N 70-15936
LYCOMING ENGINE MODEL T53-L-703 S/N LE151242
NOTES: 1. 8540 BLADES S/N 8063 AND 8109.
2. DELTA AND THETA BASED ON ENGINE INLET TOTAL PRESSURE AND TEMPERATURE (REF 19, APP A).
3. AIR BLEED AND ANTI-ICE OFF.
4. DATA OBTAINED IN HOVER AND LEVEL FLIGHT.
SYM
AVG PRESSURE ALTITUDE (FT)
AVG OAT (°C)
FLIGHT CONDITION
15800. 9.0 LEVEL FLIGHT
30600. 10.0 LEVEL FLIGHT
39200. 10.5 LEVEL FLIGHT
77000. 7.0 LEVEL FLIGHT
91200. -2.8 LEVEL FLIGHT
107800. -3.5 LEVEL FLIGHT
21200. 3.0 HOVER OGE
20200. 6.0 HOVER IGE
FAIRED CURVE FROM ENGINE CALIBRATION
REFERRED FUEL FLOW - $W_f/\delta\sqrt{\theta}$ (LB/HR)
400
500
600
700
800
900
1000
1100
400
600
800
1000
1200
1400
1600
1800
REFERRED SHAFT HORSEPOWER - $SHP/\delta\sqrt{\theta}$

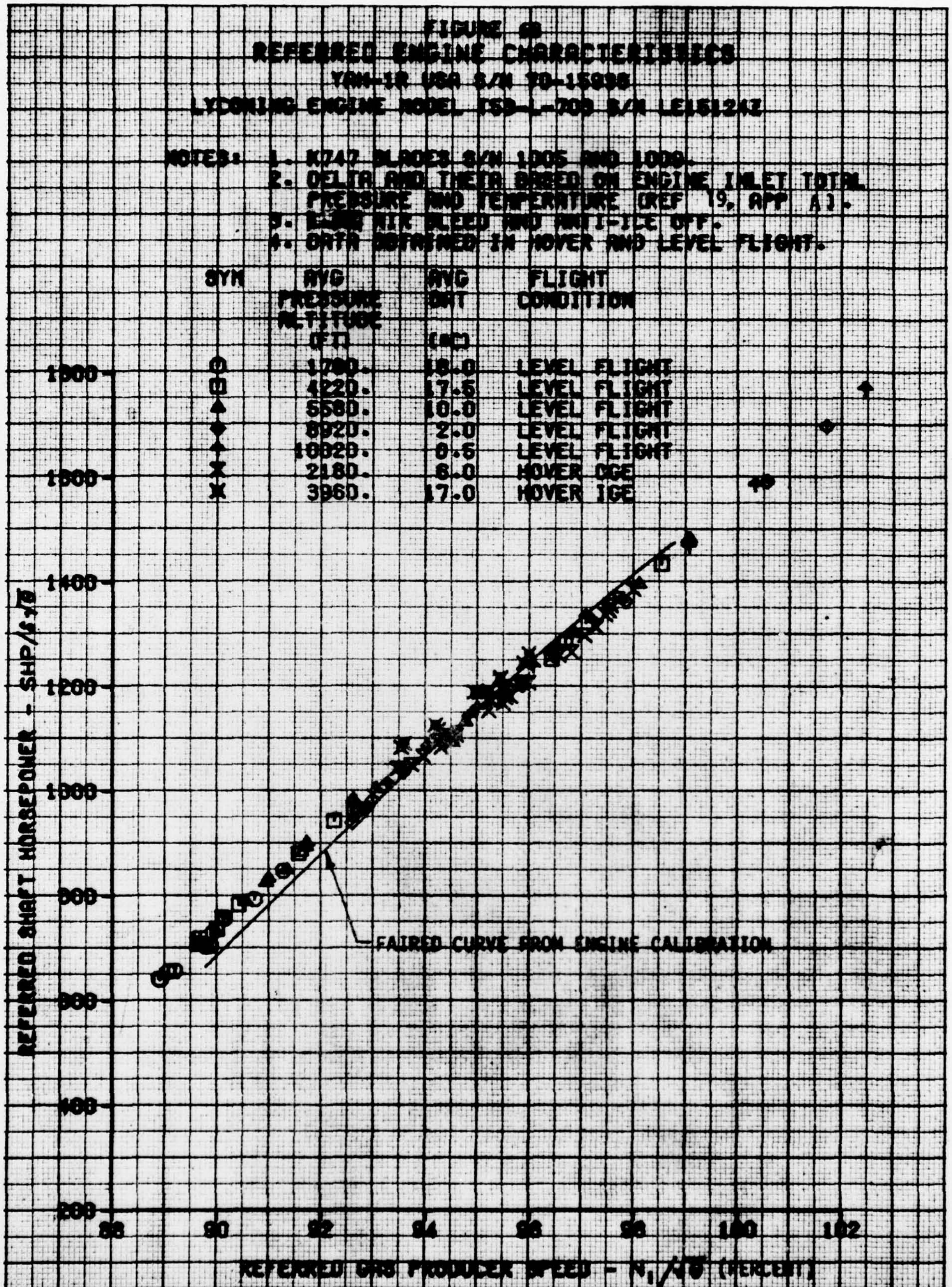
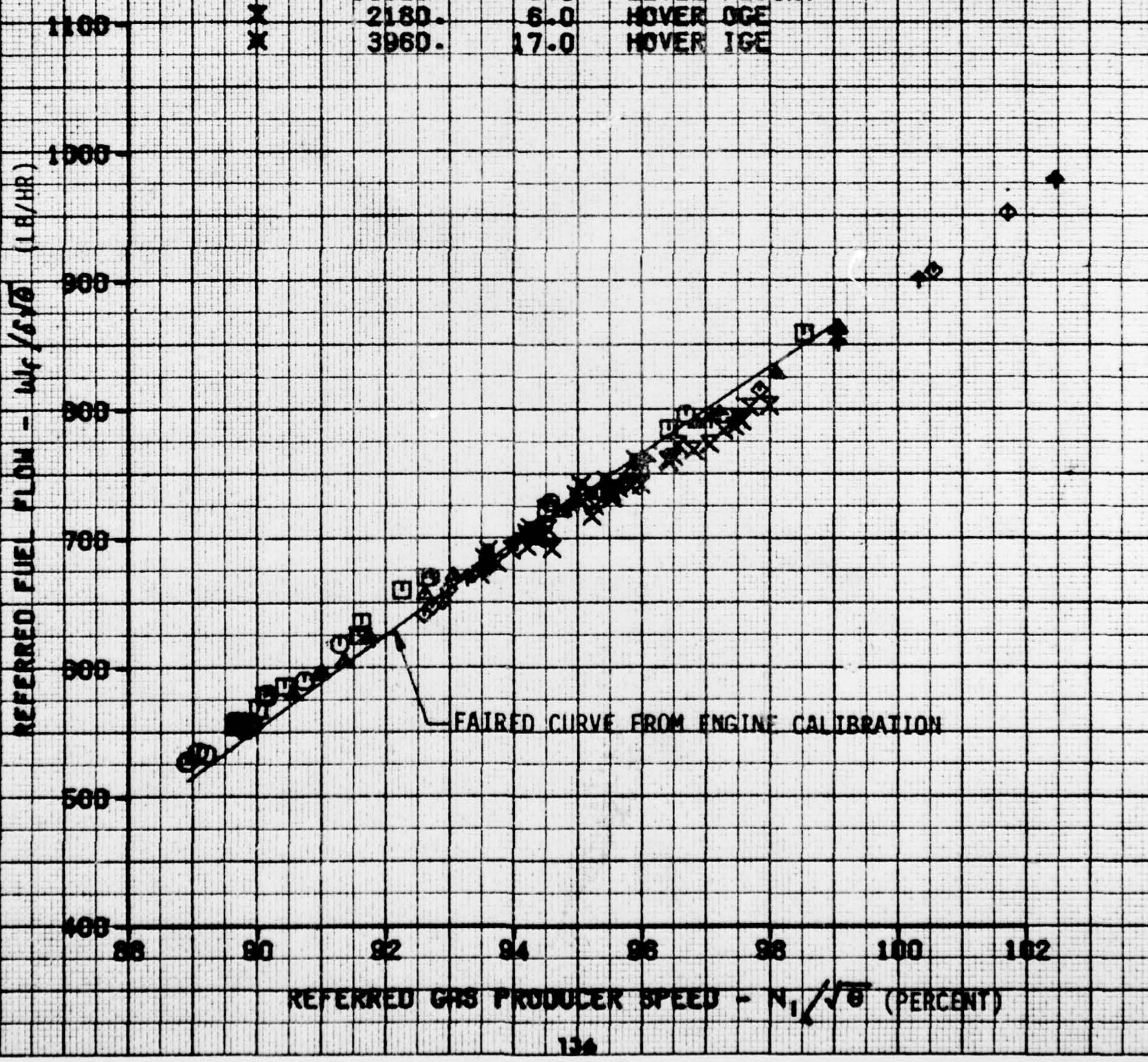


FIGURE 68
REFERRED ENGINE CHARACTERISTICS
YAH-1R USA S/N 70-15936
LYCOMING ENGINE MODEL T53-L-703 S/N LE151247
NOTES: 1. K747 BLADES S/N 1005 AND 1009.
2. DELTA AND THETA BASED ON ENGINE INLET TOTAL PRESSURE AND TEMPERATURE (REF 19, APP A).
3. AIR BLEED AND ANTI-ICE OFF.
4. DATA OBTAINED IN HOVER AND LEVEL FLIGHT.
SYM
AVG PRESSURE ALTITUDE (FT)
AVG OAT (°C)
FLIGHT CONDITION
1700. 18.0 LEVEL FLIGHT
4220. 17.5 LEVEL FLIGHT
5580. 10.0 LEVEL FLIGHT
8920. 2.0 LEVEL FLIGHT
10020. 0.5 LEVEL FLIGHT
2180. 6.0 HOVER OGE
3960. 17.0 HOVER IGE
FAIRED CURVE FROM ENGINE CALIBRATION
1800
1600
1400
1200
1000
800
600
400
200
88
90
92
94
96
98
100
102
REFERRED SHAFT HORSEPOWER - SHP/δ√θ
REFERRED GAS PRODUCER SPEED - N₁/√θ (PERCENT)

FIGURE 69
REFERRED ENGINE CHARACTERISTICS
YAH-1R USA S/N 70-15936
LYCOMING ENGINE MODEL T53-L-703 S/N LE151243

NOTES: 1. K747 BLADES S/N 1005 AND 1009.
2. DELTA AND THETA BASED ON ENGINE INLET TOTAL PRESSURE AND TEMPERATURE (REF 19, APP A).
3. [illegible] AIR BLEED AND ANTI-ICE OFF.
4. DATA OBTAINED IN HOVER AND LEVEL FLIGHT.

SYM	AVG PRESSURE ALTITUDE (FT)	AVG OAT (°C)	FLIGHT CONDITION
○	1780.	18.0	LEVEL FLIGHT
□	4220.	17.5	LEVEL FLIGHT
▲	5580.	10.0	LEVEL FLIGHT
◇	8920.	2.0	LEVEL FLIGHT
▲	10020.	0.5	LEVEL FLIGHT
X	2180.	6.0	HOVER OGE
X	3960.	17.0	HOVER IGE



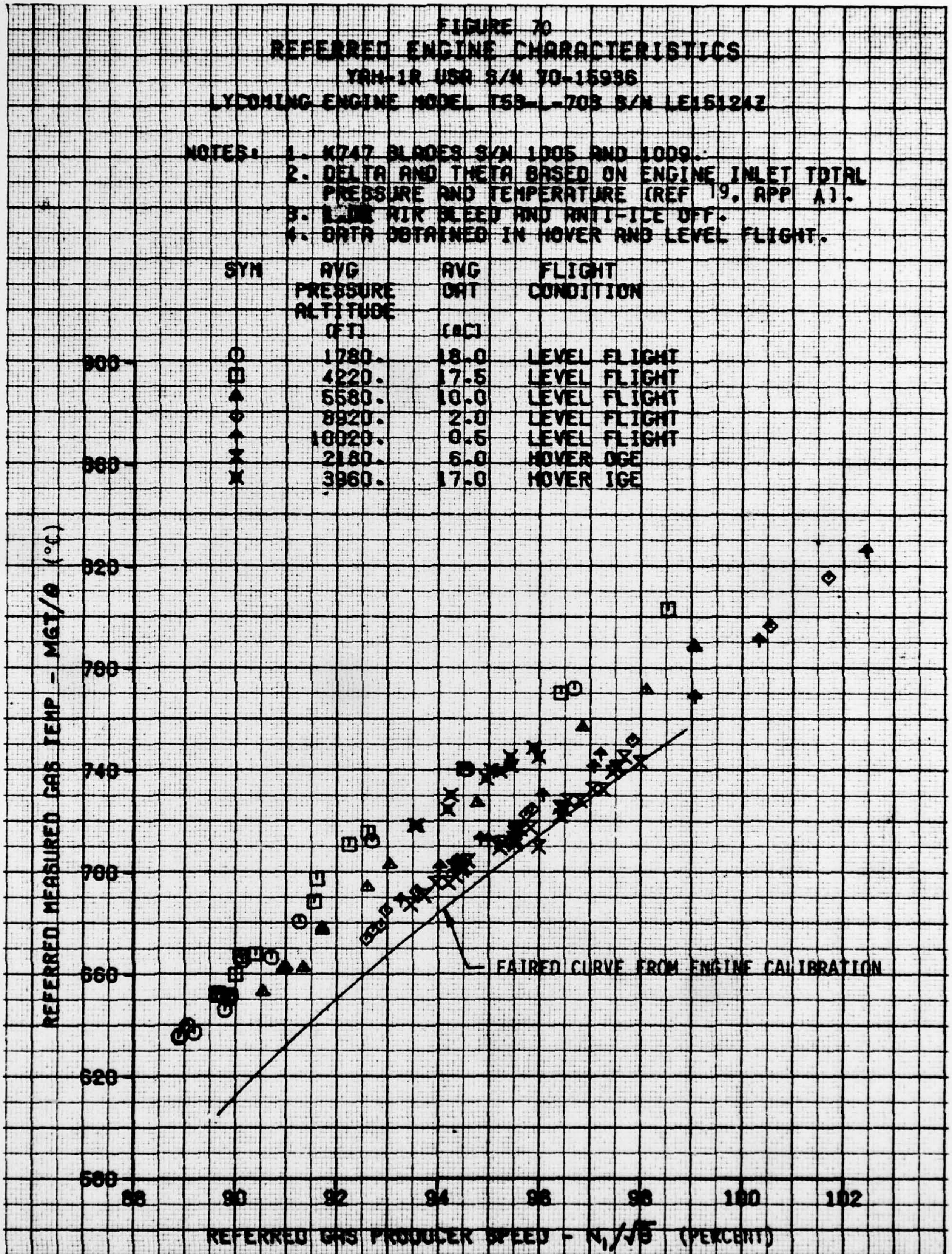


FIGURE 70
REFERRED ENGINE CHARACTERISTICS
YAH-1R USA S/N 70-15936
LYCOMING ENGINE MODEL T53-L-703 S/N LE15124Z
NOTES: 1. K747 BLADES S/N 1005 AND 1009.
2. DELTA AND THETA BASED ON ENGINE INLET TOTAL PRESSURE AND TEMPERATURE (REF 9, APP A).
3. [redacted] AIR BLEED AND ANTI-ICE OFF.
4. DATA OBTAINED IN HOVER AND LEVEL FLIGHT.
SYM
AVG PRESSURE ALTITUDE (FT)
AVG OAT (°C)
FLIGHT CONDITION
1780. 18.0 LEVEL FLIGHT
4220. 17.5 LEVEL FLIGHT
5580. 10.0 LEVEL FLIGHT
8920. 2.0 LEVEL FLIGHT
10020. 0.5 LEVEL FLIGHT
2180. 6.0 HOVER OGE
3960. 17.0 HOVER IGE
FAIRED CURVE FROM ENGINE CALIBRATION
REFERRED MEASURED GAS TEMP - MGT/θ (°C)
REFERRED GAS PRODUCER SPEED - $N_1/\sqrt{\theta}$ (PERCENT)
580
620
660
700
740
780
820
860
900
88
90
92
94
96
98
100
102

FIGURE 71
REFERRED ENGINE CHARACTERISTICS
YAH-1R USA S/N 70-15936
LYCOMING ENGINE MODEL T53-L-703 S/N LE151247

NOTES: 1. K747 BLADES S/N 1005 AND 1009.
2. DELTA AND THETA BASED ON ENGINE INLET TOTAL PRESSURE AND TEMPERATURE (REF 19, APP A).
3. [illegible] AIR BLEED AND ANTI-ICE OFF.
4. DATA OBTAINED IN HOVER AND LEVEL FLIGHT.

SYM	AVG PRESSURE ALTITUDE (FT)	AVG OAT (°C)	FLIGHT CONDITION
○	1780.	18.0	LEVEL FLIGHT
□	4220.	17.5	LEVEL FLIGHT
△	5580.	10.0	LEVEL FLIGHT
◇	8920.	2.0	LEVEL FLIGHT
▲	10020.	0.5	LEVEL FLIGHT
✕	2180.	6.0	HOVER OGE
✕	3960.	17.0	HOVER IGE

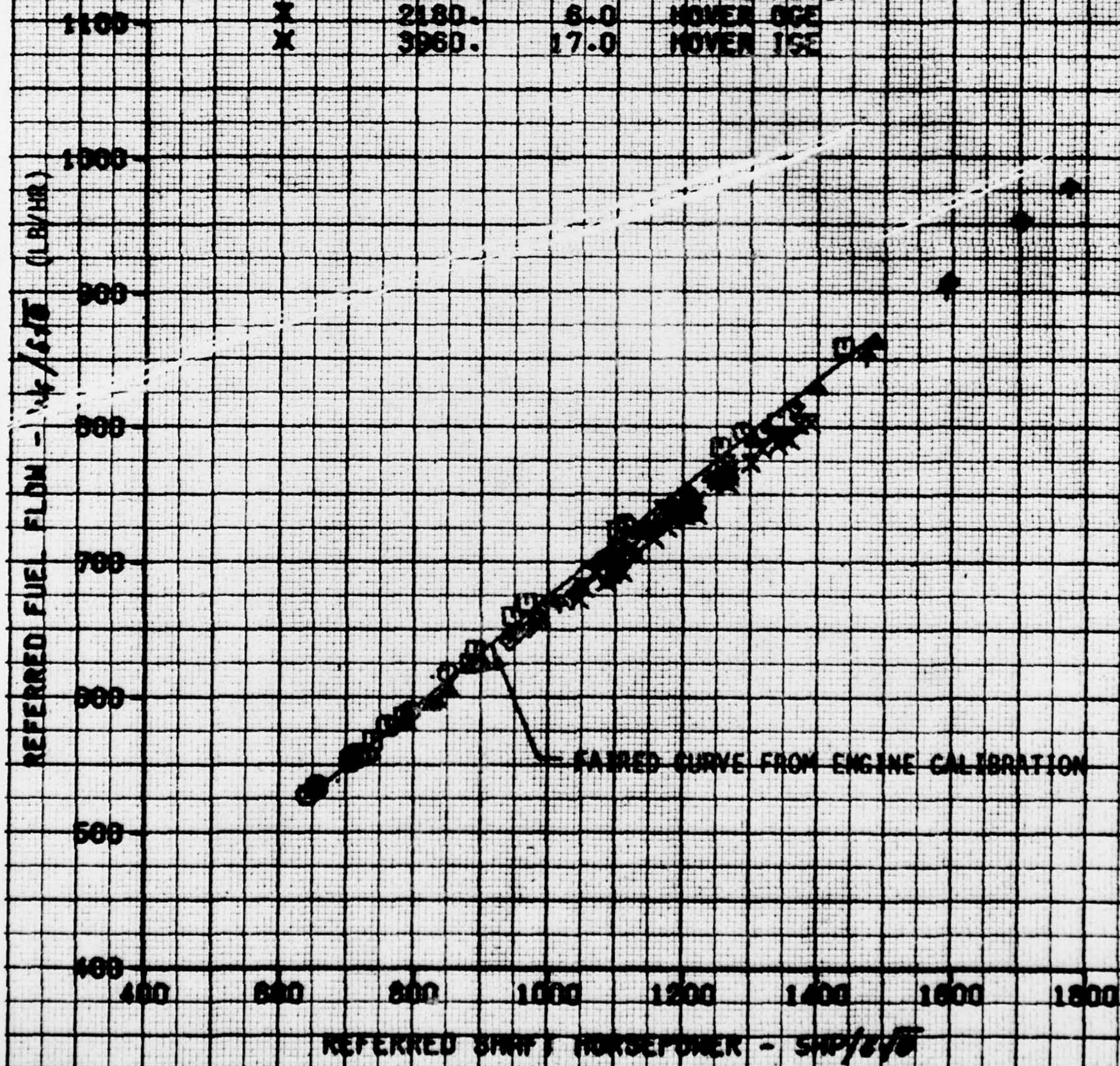


FIGURE 72
INTERMEDIATE (30 MINUTE LIMIT) POWER AVAILABLE
YAH-1R USA S/N 70-15936 T53-L-703 ENGINE
6600 OUTPUT SHAFT (324 ROTOR) RPM ZERO KNOTS TRUE AIRSPEED

NOTE: BASED ON LYCOMING T53-L-703 CARD DECK FILE NO. 19.04.32.00, CORRECTED FOR THE FOLLOWING INSTALLATION CONDITIONS:
1. ENGINE INLET TEMPERATURE RISE = 3°C
2. ENGINE INLET PRESSURE RATIO = .985
3. CUSTOMER BLEED AIR = 0.6%
4. ENGINE ANTI-ICE OFF
5. EXHAUST DUCT PRESSURE LOSS = ZERO
6. HORSEPOWER EXTRACTION = ZERO

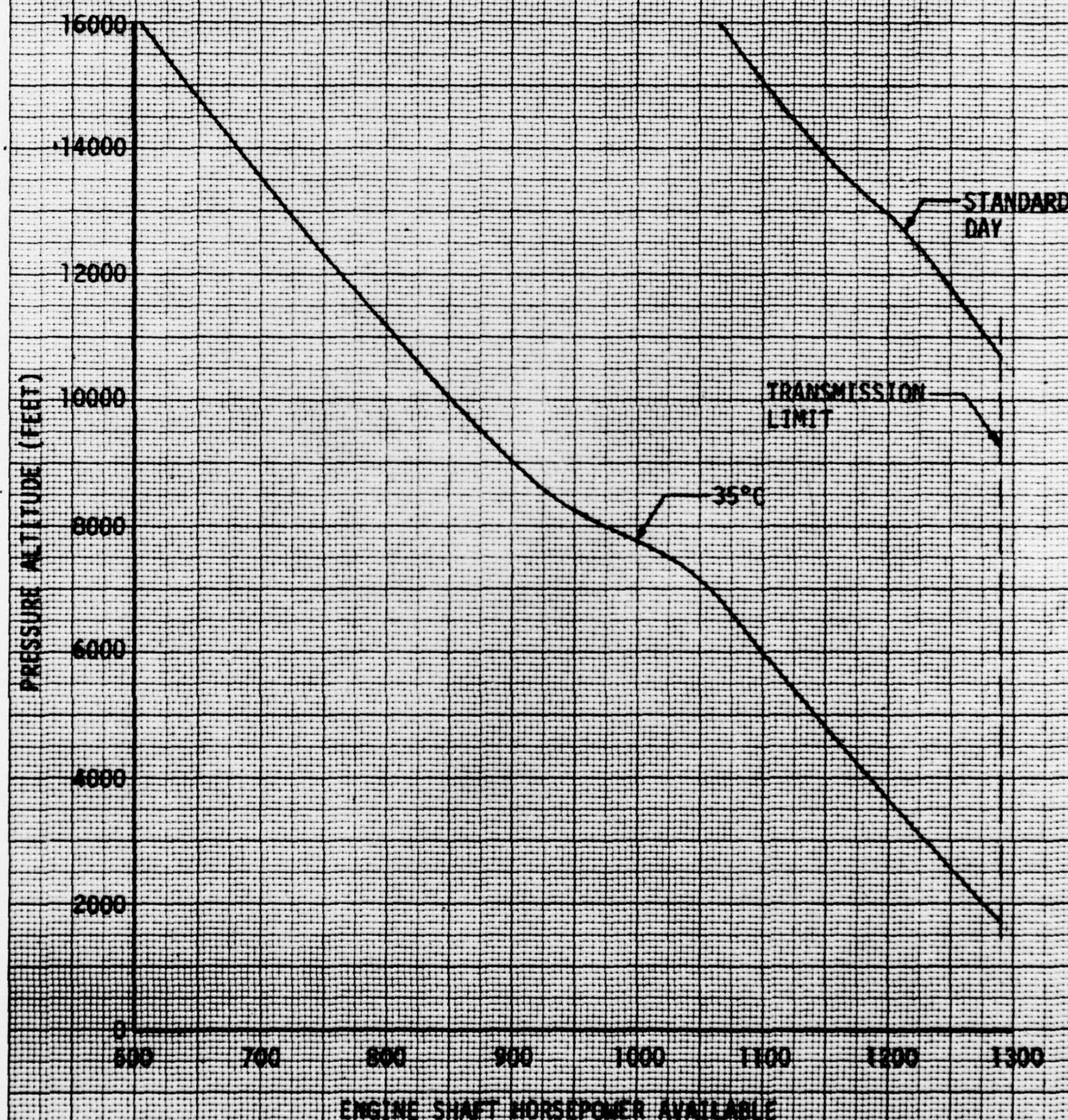


FIGURE 73
SPECIFICATION SHAFT HORSEPOWER AVAILABLE
YAH-1R USA S/N 70-15936 T53-L-703 ENGINE
6600 OUTPUT SHAFT RPM

NOTE: BASED ON LYCOMING T53-L-703 CARD DECK FILE NO. 19.04.32.00, CORRECTED FOR THE FOLLOWING INSTALLATION CONDITIONS:

1. ENGINE INLET TEMPERATURE RISE AND PRESSURE RATIO OBTAINED FROM REF. 19, APP. A
2. CUSTOMER BLEED AIR = 0.6%
3. ENGINE ANTI-ICE OFF
4. EXHAUST DUCT PRESSURE LOSS = ZERO
5. HORSEPOWER EXTRACTION = ZERO

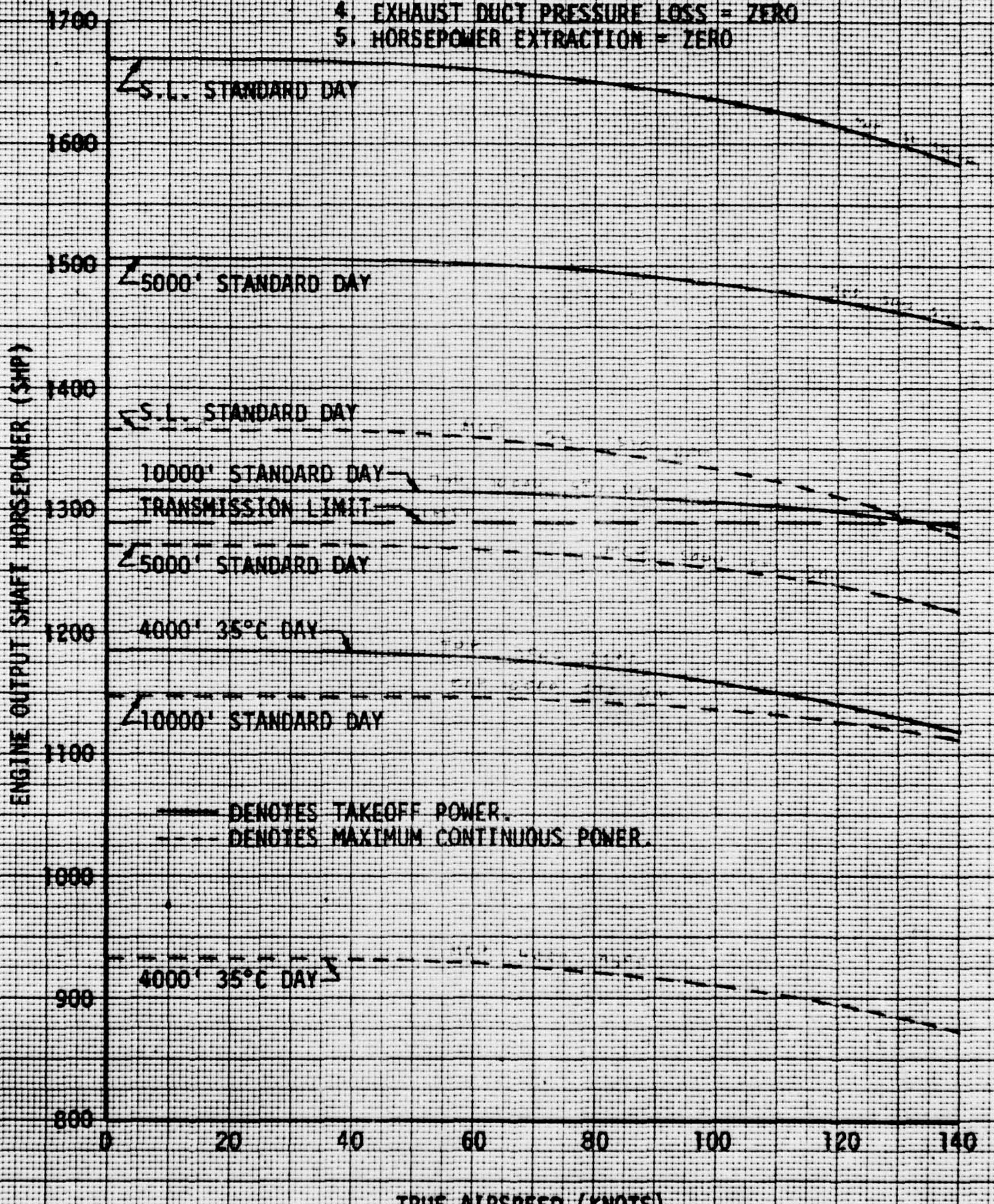


FIGURE 74
SPECIFICATION FUEL FLOW
YAH-1R USA S/N 70-15936 T53-L-703 ENGINE
6600 OUTPUT SHAFT RPM ZERO KNOTS TRUE AIRSPEED

NOTE: BASED ON LYCOMING T53-L-703 CAR DECK FILE NO. 19.04.32.00, CORRECTED FOR THE FOLLOWING INSTALLATION CONDITIONS:
1. ENGINE INLET TEMPERATURE RISE = 3°C
2. ENGINE INLET PRESSURE RATIO = .985
3. CUSTOMER BLEED AIR = 0.6%
4. ENGINE ANTI-ICE OFF
5. EXHAUST DUCT PRESSURE LOSS = ZERO
6. HORSEPOWER EXTRACTION = ZERO

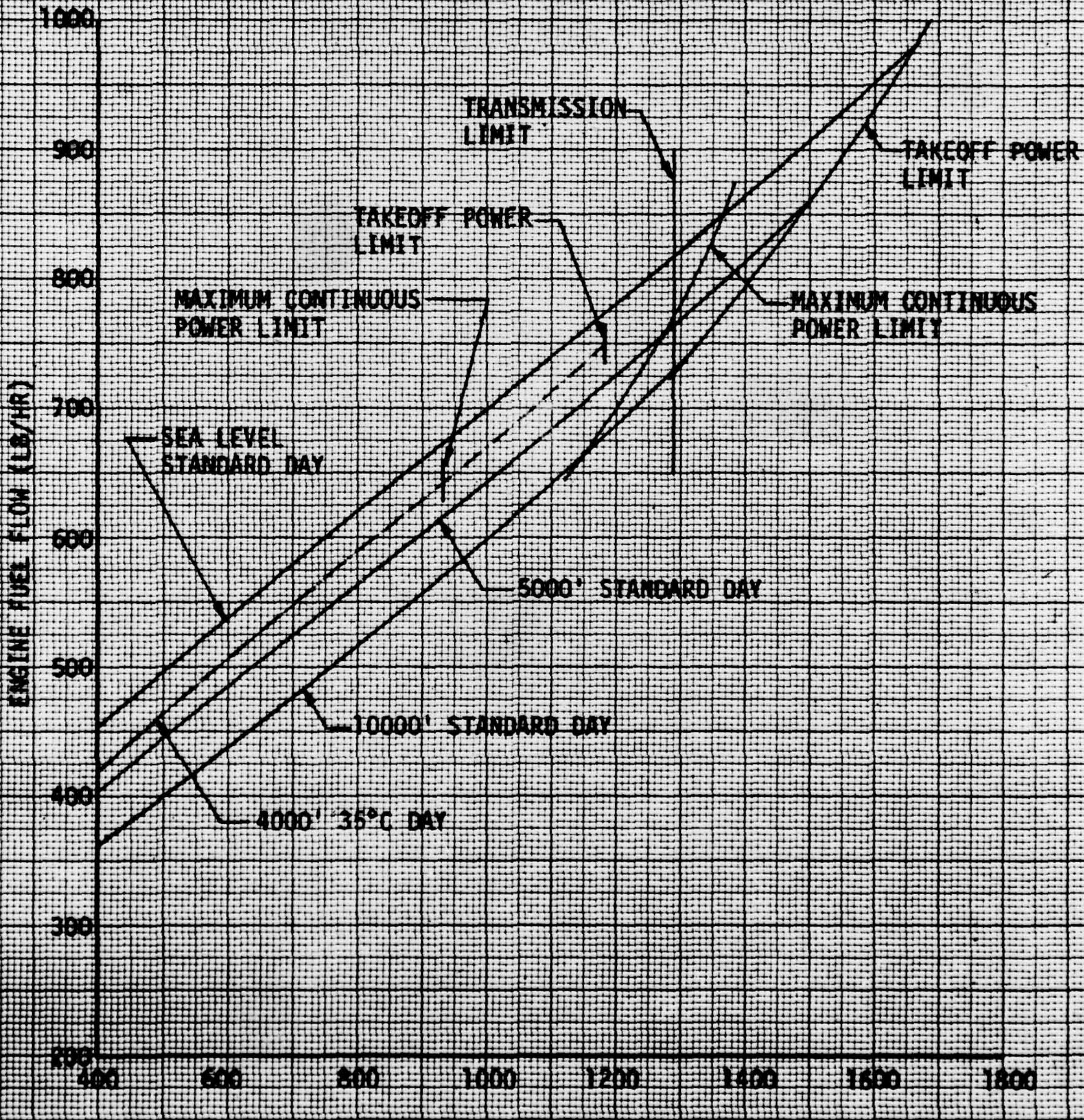


FIGURE 75

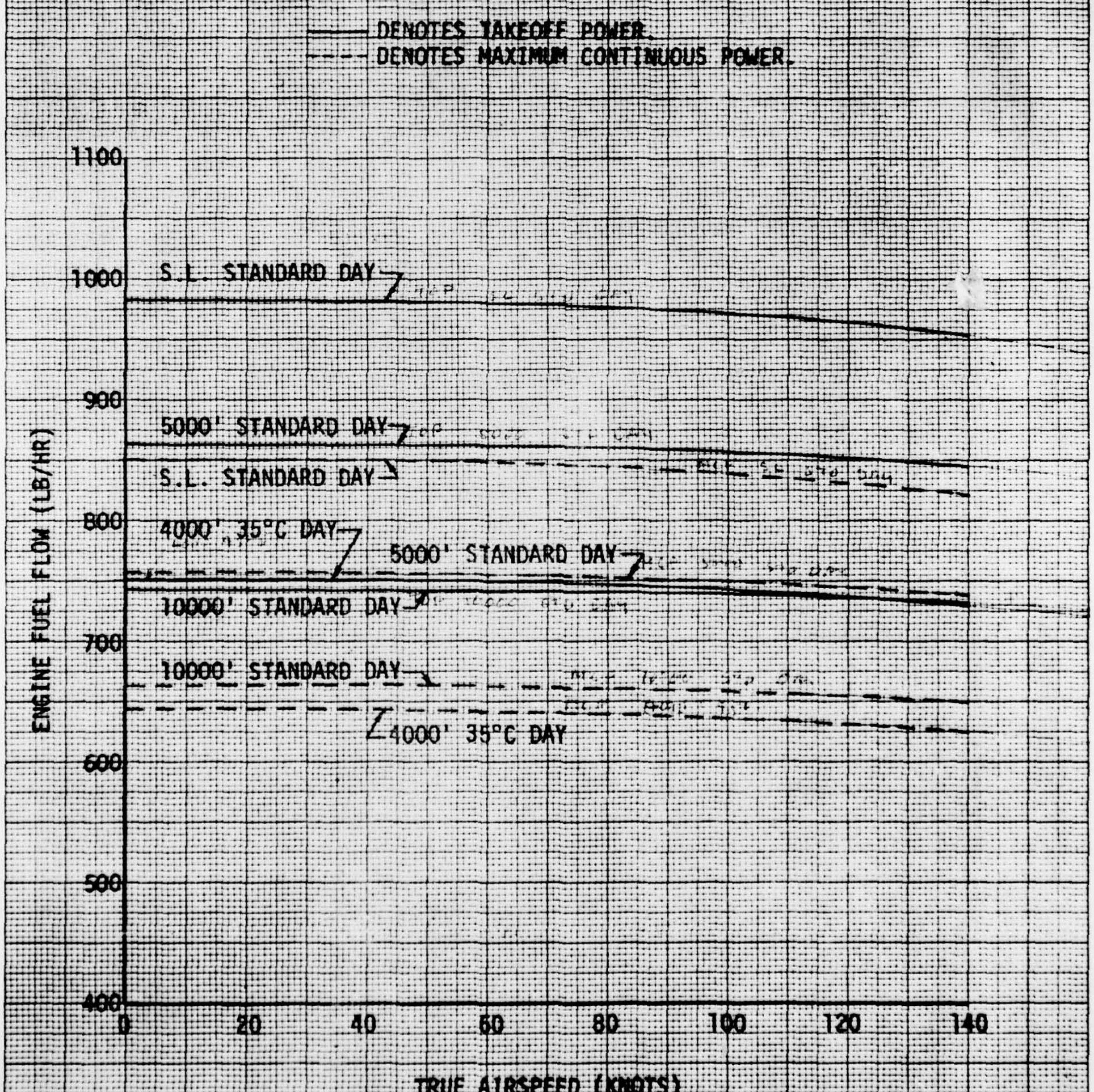
SPECIFICATION FUEL FLOW

YAH-1R USA S/N 70-15936 T53-L-703 ENGINE

6600 OUTPUT SHAFT RPM

NOTE: BASED ON LYCOMING T53-L-703 CARD DECK FILE NO. 19.04.32.00, CORRECTED FOR THE FOLLOWING INSTALLATION CONDITIONS:

1. ENGINE INLET TEMPERATURE RISE AND PRESSURE RATIO OBTAINED FROM REF. 19 , APP. A
2. CUSTOMER BLEED AIR = 0.6%
3. ENGINE ANTI-ICE OFF
4. EXHAUST DUCT PRESSURE LOSS = ZERO
5. HORSEPOWER EXTRACTION = ZERO



APPENDIX F. EQUIPMENT PERFORMANCE REPORTS

The following EPR's were submitted during testing of the Kaman IMRB.

EPR NO.	DESCRIPTIVE TITLE
76-08-01	Rotor blade shipping containers
76-08-02	Main rotor blade/transmission fairing contact under static conditions
76-08-03	Crack on tip of main rotor blade
76-08-04	Crack in main rotor blade in the blade-to-hub attachment area
76-08-05	Two cracks on top surface of main rotor blade

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